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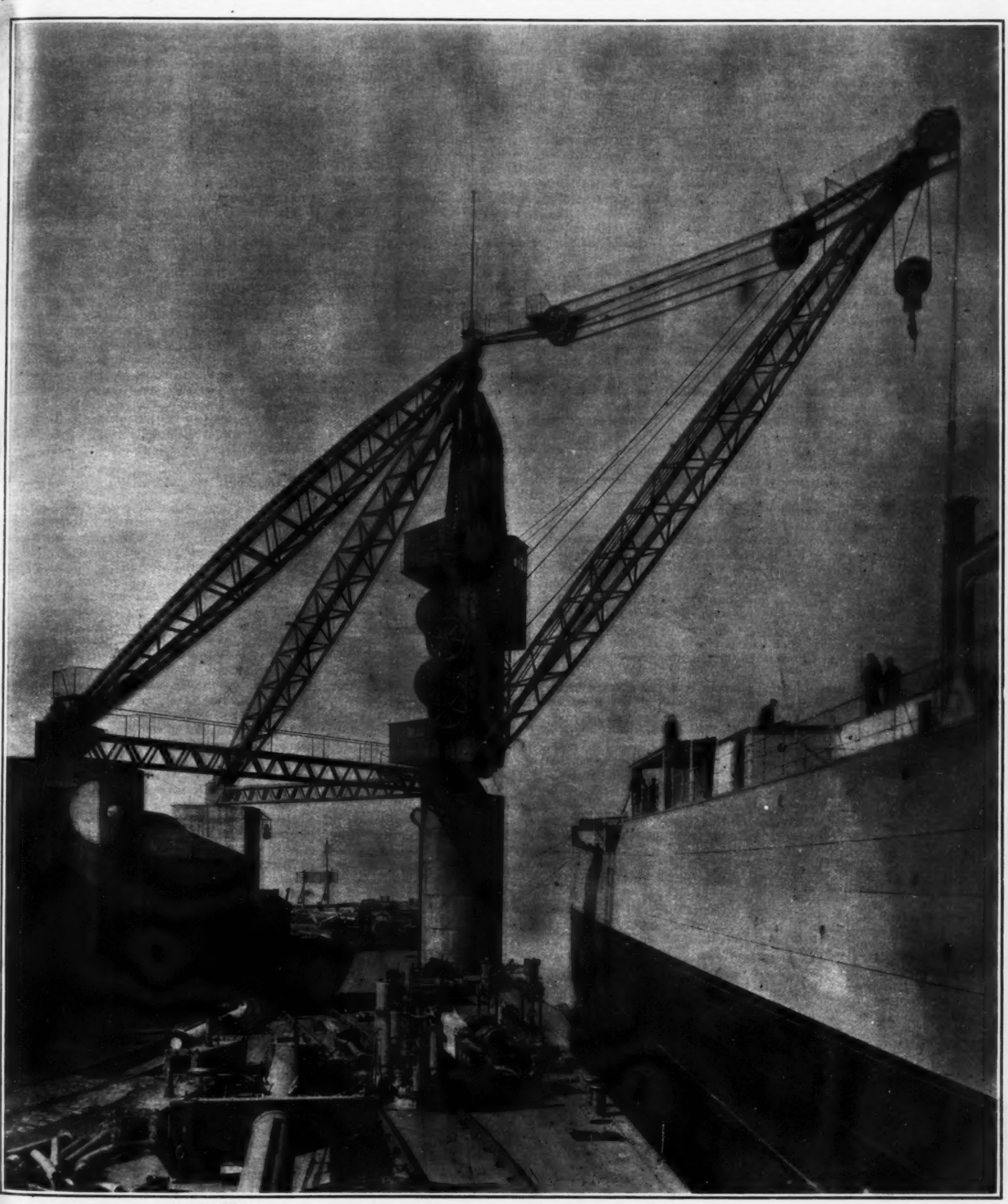


A 100-TON ELECTRIC CRANE USED IN A SCOTCH SHIPYARD.

FLOATING CRANES.—[SEE PAGE 279.]

USE OF GAS FROM A HYGIENIC STANDPOINT.*

WHAT GAS MEANS IN A BUILDING.

BY PROF. VIVIAN B. LEWES

The effect of burning coal gas as an illuminant on the air of our dwelling rooms and the health of its occupants is as old a subject as the use of coal gas itself, and in the early days of the gas industry threatened to wreck its future for indoor illumination, as the crude gas then sent out, rich in sulphureted hydrogen, gave rise to such discomfort when consumed that ventilating burners of clumsy device had to be employed for its use, while badly made and leaky fittings gave at all times an aroma which suggested to the nose and mind of the householder a doubt as to the sanitary condition of the drainage.

A very short period, however, served to convince the gas manager that the purity of the gas was a matter of even greater importance to him than to the public, as the latter could escape the effects of the sulphurized products of combustion by adopting other illuminants, while the gas manager's livelihood depended on keeping his customers, and as a result purification from sulphureted hydrogen was adopted, and the use of coal gas increased with enormous rapidity, the public being convinced by experience that properly used the coal gas in no way injuriously affected their health.

With the advent of the electric light as an illuminant, great stress was laid upon its enormous advantages from the hygienic point of view, and its supporters still make the claim that it must of necessity be far more healthful to use as an illuminant than coal gas. It has not unnaturally been assumed that owing to incandescent electric lighting adding nothing to the impurities in the atmosphere and, what is quite as important, withdrawing no oxygen from it, it must be the most hygienic form of illumination to employ; but in the years which have elapsed since electricity was pressed into the service of man for illuminating purposes it has become perfectly clear that, although it is inactive as regards vitiation of the atmosphere, a gas-lighted room will nearly always be more pleasant and healthy to live in than one lighted by the newer form of illuminant.

I have in my mind at the moment a hall which in the old days was lighted by gas and in which a large audience could, with comfort, sit through an hour's lecture or, with pleasure, through a three hours' dinner, but which with the march of civilization had its illumination changed from gas to electricity, the latter being employed with all the latest refinements to effect the lighting under the best conditions, with the result that any large gathering within its walls leads to a state little short of asphyxiation, and it is with the various factors that lead to this anomaly I now desire to deal.

Owing to the peculiar nature of the question, embracing as it does both chemical, physical, and physiological considerations, it is impossible to treat it from any one of these points alone, and in order to make it clear one must review the various data involved, although many of them are well known to you.

The atmosphere is composed mainly of two elementary gases, oxygen and nitrogen; the oxygen is the great supporter of life and combustion, and is the agent employed by nature in those cleansing processes chief among which is "decay," while the nitrogen serves to dilute the oxygen and keep its action within the proper limits. These two gases are present in the air in the proportion of 20.9 per cent of oxygen to 79.1 per cent of nitrogen by volume, or roughly one volume of oxygen to four of nitrogen. Besides these, however, we find traces of other bodies in the atmosphere, some of which, like water vapor, carbon dioxide and ammonia, are necessary for the carrying on of nature's processes, while others are the true impurities, and generally have a local origin.

The oxygen used up daily by processes of animal life, combustion and decay amounts, according to the calculations of Faraday, to no less than three and a half million tons, and it is replaced in the atmosphere by the products evolved by these actions, namely water vapor and carbon dioxide, yet analyses continued over the past hundred years have failed to detect any diminution in the quantity of oxygen or increase in the amount of carbon dioxide, so that it is manifest that nature must have at hand some method not only for the removal of carbon dioxide from the air but also for the production of oxygen, as otherwise the atmosphere would rapidly deteriorate and become unfit to support life.

The main factor in this marvelous natural work is to be found in vegetation, the waste products from the animal world being utilized for building up the vegetable kingdom, an action by which the oxygen is replaced in the atmosphere and keeps it in a condition fit for breathing, while other impurities are partly washed out from the air by rain and partly oxidized and destroyed by ozone. The wonderful power of diffusion possessed by gases is the chief factor in keeping the composition of the atmosphere constant, as aided by air currents and wind it keeps the whole of the gases present so thoroughly intermixed that it took scientific observers half a century to discover whether these gases were really only mixed together in the atmosphere or in chemical combination.

In the open air these provisions of nature are ample to maintain the air in a healthy condition for breathing, but it is when we are in an inclosed space, such as a room, that we interfere with the work of purification, so that the air in the room rapidly becomes fouled by the products of respiration, and unless we take special means to aid nature in the revivification of the air it rapidly becomes unfit to be rebreathed, and our health suffers in consequence.

One of the most wonderful of the many marvelous process taking place in our bodies is that which really forms the great mainspring of life. We build up our bodies from the foods and liquids which we assimilate, and the tissue so produced is then consumed in the body by a process of slow combustion taking place at the expense of the oxygen which, inhaled into the lungs, is carried by the circulation of the blood throughout the body, and burning up the tissue generates the energy for every action voluntary or involuntary and gives the warmth to the body which exists while life lasts.

The products given off during the process of respiration are the gas carbon dioxide, exhaled from the lungs as we respire, water vapor and traces of organic matter, and the air which has been once breathed is unfit for further respiration until nature has dealt with it by her cleansing processes.

The air in the country contains on an average three parts of carbon dioxide in 10,000, while in the towns the proportion is generally four parts in 10,000, and this latter figure is usually taken as the proportion present in normal air. In a room, however, in which people are breathing the air the amount of carbon dioxide will increase, and when it has reached six parts in 10,000 the atmosphere of the room will become noticeably fouled to the nose of any one entering from the fresh air and is what we call "stuffy."

This is due to the presence of organic matter evolved from the skin and lungs during respiration and not to the slight excess of carbon dioxide, which is absolutely harmless, but the organic matter is excessively deleterious to health and, moreover, often contains the germs of disease. When produced in this way by respiration the proportion of carbon dioxide and organic matter increase at the same ratio, and as it is fairly easy to estimate the amount of carbon dioxide in the air and extremely difficult to determine the organic matter, the condition of the atmosphere in inclosed spaces is generally investigated by determining the percentage of carbon dioxide present. The sanitary limit allowable has been taken at six volumes of carbon dioxide in 10,000 of air, but although this is perfectly correct when the source of the pollution is respiration, yet the proportion may be far higher when the carbon dioxide is generated by processes of combustion without in any way injuriously affecting health.

In the ordinary dwelling house the attempts at ventilation are of the most primitive and inefficient character; indeed, in the majority of households the efforts of the inhabitants seem to be directed to getting the rooms as nearly air-tight as possible in order to render them warm, but this soon serves to render the air so vitiated as to be unfit for breathing.

In the course of 10 hours a man breathes out 6 cubic feet of carbon dioxide, and as the air already in the room contains four parts of carbon dioxide in 10,000, in order to reach the sanitary limit he can only add two parts more carbon dioxide to each 10,000 of air, so that in the 10 hours he must be supplied with 30,000 cubic feet of fresh air; in other words, if the air of a room be not changed it must be of sufficient size to contain 3,000 cubic feet if it is to be inhabited by him for one hour, while in the bedroom, in which he is to spend seven hours, it would have to be of 21,000 cubic feet capacity. This is manifestly an impossibility, therefore arrangements are made by which the air in a room can be constantly changed; and as this can be done three or four times in an hour, without creating draughts, the air supply can be diminished to 750 to 1,000 cubic feet per inhabitant per hour in rooms which are to be occupied for any length of time, and this is the basis on which the ventilation of properly constructed buildings is arranged.

It is the organic matter given off from the lungs and tissues during respiration that it is essential to remove from the air, and before one can condemn the atmosphere in an inclosed space by mere analysis, the source from which the carbon dioxide was produced must be known, as without the presence of the organic matter it is possible to live in an atmosphere containing 20 parts of carbon dioxide in 10,000 without injury to health.

In all processes of ventilation the great factors which enable us to change the atmosphere in our dwelling rooms are the air currents set up by alterations in temperature and inter-diffusion between volumes of air at different temperatures and it is this which gives coal gas its great advantages as an illuminant over electric lighting.

The combustion of 1 cubic foot of coal gas will use up 6 cubic feet of air, giving approximately ½ a cubic foot of carbon dioxide and nearly 1½ cubic feet of water vapor. Using an incandescent mantle on an atmospheric burner, about 4 cubic feet of gas per hour are consumed, and this gives 2 cubic feet of carbon dioxide, which would very soon suffice to raise the proportion of carbon dioxide above the sanitary limit of six parts in 10,000; but although everything be done to render the room as air-tight as possible it will be found that the proportion of carbon dioxide is enormously less than it should be by theory, this being due to the fact that alterations in the temperature of the air of the room set up currents and actions which tend to bring about a change of the atmosphere.

Carbon dioxide is a gas considerably more heavy than air, so much more so indeed that it can be poured from one vessel to another almost like a liquid, but like all other gases it is expanded by heat, and as the foul air coming from the lungs containing some 5 per cent of carbon dioxide is at practically the temperature of the body, that is, 98 deg. Fahr., it at once rises toward the ceiling, while the products of combustion from the gas burner, being at a still higher temperature, also rush up to this point, so that the foul air is always to be found at the top of the room.

One might think that this foul air when cooled down would descend into the room again, but here the process of diffusion comes into play, a process by which gases instead of arranging themselves like other forms of matter according to their weight, undergo a mingling or diffusion, the rate of such mingling being dependent upon their weight, a light gas mixing rapidly with others while a heavy gas diffuses more slowly. It is found that once mingled the gases remain in perfect admixture, so that in the present case the heavy carbon dioxide will not again separate from the air into which it has become diffused.

This so-called diffusion of gases can be and is experimentally shown in many ways and will take place with even greater rapidity through porous solids than when the gases are left simply in contact with each other, and as the plaster of the ceiling and the bricks or other building material of which the rooms are composed are full of minute openings or pores, they allow gases to diffuse through with considerable rapidity, the force of diffusion being aided by a second force called capillarity. The result is that even though the ventilation of a room has been neglected and no proper outlet has been arranged at the top for drawing off foul gases, diffusion through the ceiling and through the walls in the upper part of the room provides so rapid an egress for the hot gases that they have not time to mingle with the air in the lower portion of the room, while fresh air is being constantly drawn in through every crack and crevice left by the jerry builder.

All interesting series of experiments which I have made, show conclusively that taking an ordinary dwelling room lighted by gas and then the same room lighted by electricity, the air of the lower portion of the room, if one or two people only are present, is as pure with gas lighting as with electric lighting, while if a large number are present the advantages are enormously in favor of gas, the air with electric lighting becoming rapidly so organically impure as to be positively dangerous to health.

* Lecture delivered before the British Institution of Gas Engineers at Dublin, Ireland.

DISTRIBUTION OF CARBON DIOXIDE IN THE AIR OF A DWELLING ROOM WITH GAS AND ELECTRIC INCANDESCENT LIGHTING.

Capacity of room, 2,700 cubic feet.

Gas Lighting.—Two Welsbach "C" burners on pendant, consuming 4 cubic feet of gas each per hour, and giving 140 candles.

	Carbon dioxide; parts per 10,000	Temperature; deg. Fahr.
Outside air	0.03	61.0
Between joists	0.06	66.0
Ceiling level	0.44	74.7
Breathing level	0.05	63.0

Electric Lighting.—Three 16-candle power lamps.

	Carbon dioxide; parts per 10,000	Temperature; deg. Fahr.
Outside air	0.03	61.0
Between joists	0.04	61.5
Ceiling level	0.09	62.5
Breathing level	0.06	61.7

If a number of people be in a room the organic exhalations as well as the carbon dioxide and water vapor evolved during respiration rise, and reaching the level of the gas burners are rapidly swept up to the ceiling by the rush of hot gas from the burner, the flame and heat destroying and charring a large proportion of the germs. The hot air reaches the ceiling and diffuses through the plaster and walls in the upper part of the room. And in doing so the charred organic matter is left behind filtered off on the surface of the plaster and rapidly causes that discoloration of the ceiling which you invariably find in a town atmosphere above the gas burner, and which is often wanting with country air. That this is the case is amply verified by the fact that if beams are present at the back of the plaster, diffusion is prevented at those points, and their position is plainly mapped out on the discolored surface.

When the room with its occupants was lighted by electric light there was no rapid uprush in this way of the products to the ceiling, and the organic impurities and carbon dioxide leaving at body temperature remained diffused throughout the whole of the atmosphere of the room, causing a far more rapid fouling of the air and injury to health. If such a room were entirely left for its ventilation to diffusion through the walls, it would soon acquire that sour smell which is noticeable in many rooms of the poor, in which in order to keep in the warmth derived from their own bodies all ventilation is cut off. This smell is due to the decomposition of organic matter filtered off during diffusion by the wall surface and undergoing putrefactive decay giving the offensive odor, the only way to get rid of which is to strip the paper from the walls and lime wash them as well as the ceiling; then only does the smell disappear.

When, however, this same diffusion through the ceiling and upper part of the walls of the room takes place in a gas-lighted room, this unpleasant human smell, so characteristic of the "tube" railways, never appears, as the small quantity of sulphur compounds present in the gas (as was shown by the researches of Drs. Hehner and Rideal) is largely absorbed and fixed by the lime and lime salts present and acts as a disinfectant, destroying all forms of germ life. Here again the hygienic superiority of gas becomes manifest, as in a gas-lighted room or hall not only are the germs present in the air, and often of an infectious character, destroyed and burned up by the flame itself, but also undergo destruction and disinfection from the trace of sulphur dioxide present in the products of combustion, an action which is entirely wanting when the illumination is due to incandescent electric light.

An interesting point also brought out by the experiments I have made is that it is really the position of the gas light above the level of the head in the chandelier which causes this hygienic advantage and that if the gas is burning in table lamps the cooling of the products in their passage up to the ceiling largely does away with the ceiling action, and the air of the room may become as foul as when unlit or lighted by electric light.

(To be continued.)

DISTILLATION OF SOFT WOOD.

PRACTICAL SUGGESTIONS FOR THE INDUSTRIAL CHEMIST.

In distilling pine and other coniferous woods, the results are somewhat different from those obtained by the dry distillation of hardwood, such as beech. There are three methods of handling these materials, just as there are for working with hardwood. The first is the usual way in Hungary and other wooded countries; the second that employed in America; the third the new European process.

The Hungarians have for their principal object the manufacture of lime acetate and wood spirit; the Americans, the production of charcoal.

Starting with 100 cubic meters (3,531 cubic feet or 27.58 cords) of air-dried pine in the retort, weighing 740 kilogrammes = 1,628 pounds average, we get as our first products:

(a) 9,500 kilgs. = 20,900 pounds of charcoal,
(b) 6,500 kilgs. = 14,300 pounds of gas, and
(c) 21,500 kilgs. = 47,300 pounds of crude wood vinegar and tar.

This latter mixture is allowed to settle, to separate the two substances, so that then there are

(d) 16,500 kilgs. = 36,300 pounds of crude vinegar, and
(e) 4,000 kilgs. = 8,800 pounds of crude tar.

Distilling the vinegar and treating the vapors with milk of lime (after separating the wood spirit that at first comes over) there are obtained:

(f) 6 to 10 per cent of retort waste, weighing 1,200 kilgs. of tar, free from water,
(g) 12,000 kilgs. = 26,400 pounds average of 7½ per cent acetate of lime lye,
(h) 2,000 kilgs. = 4,400 pounds of 10 per cent crude wood spirit,
(i) 4,000 kilgs. = 8,800 pounds steam.

The lye (g) is evaporated by steam and there are obtained therefrom

(j) 10,200 kilgs. = 22,440 pounds of steam, and
(k) 1,800 kilgs. = 3,960 pounds of 50 per cent lime acetate.

This latter being evaporated by the combustion gases from the retorts, yields 900 kilgs. = 1,980 pounds of steam, and

(l) 900 kilgs. = 1,980 pounds of bone-dry lime acetate.

The crude tar being distilled to free it from water, yields

(m) 400 kilgs. = 880 pounds of crude wood vinegar (sent to join product d),
(n) 2,550 kilgs. = 5,610 pounds of water-free tar, and
(o) 1,056 kilgs. = 2,310 pounds of crude turpentine, which is afterward refined.

The 400 kilgs. = 880 pounds of crude vinegar are sent to join the 16,500 kilgs. = 36,300 pounds of the same substance (product d from product b).

The American system, starting with the same 100 cubic meters = 3,531 cubic feet or 27.58 cords of air-dried pine, yields after the several initial operations the same products (d) and (e) as the old European method; but from this on, the process is different.

(e) is distilled to free it from wood vinegar, and yields

(n) 2,550 kilgs. = 5,610 pounds of water-free tar,
(o) 1,100 kilgs. = 2,420 pounds crude spirits of turpentine, which are afterward distilled, and
(p) 400 kilgs. = 880 pounds of crude wood vinegar.

The 16,500 kilgs. = 36,300 pounds of crude wood vinegar (d) proceeding from c is mixed with the 400 kilgs. = 880 pounds of the same substance made from e and distilled; the products being

(q) 15,700 kilgs. = 34,500 pounds of distilled wood vinegar, and
(r) 1,200 kilgs. = 2,640 pounds of water-free tar.

This latter, being allowed to settle, holds

(s) Various wood oils, and
(t) 15,700 kilgs. = 34,540 pounds of distilled wood vinegar.

This latter is mixed with 1,500 kilgs. = 3,600 pounds of milk of lime to neutralize it, and yields

(u) 17,200 kilgs. = 37,840 pounds of acetate of lime lye.

By simple distillation this latter is freed from wood spirit, and yields

(v) 1,600 kilgs. = 3,520 pounds of 15 volume per cent wood spirit, and
(w) 15,600 kilgs. = 34,320 pounds of lime of acetate lye.

Product v is rectified in a compound still (not in a simple one as in Hungary), and yields 860 kilgs. = 1,892 pounds of 42 volume per cent of wood spirit, and 1,040 kilgs. = 2,288 pounds of water and various oils.

(u) Being rectified in a compound still, there results

(y) 264 kilgs. = 580 pounds of crude wood spirit of 80 volume per cent, and
(x) 296 kilgs. = 651 pounds of water and oils.

Product (u) being filtered and evaporated by steam, yields

(x) 13,800 kilgs. = 30,360 pounds of steam, and
(y) 1,800 kilgs. = 3,960 pounds of 50 per cent lime acetate. This latter being further evaporated by the combustion gases, there result
(y′) 900 kilgs. = 1,980 pounds of water, and
(y″) 900 kilgs. = 1,980 pounds of gray acetate of lime.

By the improved European method of working, we start with 100 cubic meters of wood as before; but get, instead of the three products obtained by each of the other two processes,

(A) 9,500 kilgs. = 20,900 pounds of charcoal,
(B) 15,700 kilgs. = 34,540 pounds of clear vinegar,
(C) 3,750 kilgs. = 8,250 pounds of water-free tar,
(D) 1,050 kilgs. = 2,310 pounds of crude spirits of turpentine, and
(E) 6,500 kilgs. = 14,300 pounds of gas.

Product B being neutralized with milk of lime, there are obtained

(F) Acetate of lime lye; which being distilled yields
(G) 80 to 90 per cent of crude wood spirit, and
(H) Alcohol-free solution of lime acetate.

This latter, being evaporated by steam, yields

(I) A 50 per cent solution of lime acetate, which being made bone dry by steam, gives as the last product,
(J) Gray acetate of lime of 80 to 82 per cent strength.

One most important material which has been neglected—that is, thrown away or imperfectly distilled—is very adaptable for the manufacture of charcoal and the by-products, wood spirit and acetate of lime—the roots; and especially those of pine and similar timber. The roots ordinarily yield only one-half as much spirit as the trunk and branches, while the expense of labor is greater. They have, to be sure, the disadvantage that they yield in addition to wood spirit, etc., turpentine and the so-called "Swedish tar oil."

In the distillation of wood there are or may be obtained the following products: Charcoal, charcoal brickets, brown acetate of lime, crude wood spirit, refined wood spirit, pure methyl, "Columbia spirit," acetic acid of various grades, "vinegar essence," acetone, anhydrous tar, tar oils, and crude spirits of turpentine, white odorless pine oil, pine tar oil, crystallized soda acetate, anhydrous soda acetate, formaldehyde, and paraformaldehyde.

The distillation takes from sixteen to thirty-six hours, according to the amount of wood, the character of the retort, the temperature therein, the amount of the charge, etc.

The "Swedish tar" consists of tar from coniferous timber, with the addition of the resinous oils which distill over with it, and which give it a pliability very much prized.

In obtaining turpentine from soft wood, there has been employed ordinary saturated live steam; but in this case the steam consumption is usually excessive. If, however, superheated steam be used, the turpentine obtained will be mixed with products of decomposition of the wood.

A kiln of 200 to 300 cubic meters, or say 7,000 to 10,500 cubic feet (55 to 82 cords of 128 cubic feet each) capacity, requires for filling, distilling, and discharging, about fifteen to twenty days. Smaller clamps, however, of say 30 cubic meters, 1,059 cubic feet, or 8.2 cords capacity, take but four or five. More time is required in winter than in summer.

HORN WASTE.

Utilization of Turnings and Filings.—The waste is first well wetted with a highly saturated solution of potash, and then a solution of lime—lime hydrate—is poured over it, in which the waste is cleansed and after standing a considerable time transformed into a jelly-like mass. In this form, if moderately heated, it can be poured and pressed into any desired shape, after which the moisture is expelled from the substance which acquires a solid consistency. A second pressing, with application of heat, gives the molded mass the completed form and it can then be worked up into pipe mouth-pieces, cigar-tips, cane and umbrella handles, buttons, etc.

Horn waste can also be utilized as follows: Turning, rasping, or filing chips in a moistened condition, are pressed into a solid cake in a cylindrical mold by a metallic piston, heat being applied at the same time. The mass thus obtained is rasped down to a fine powder, which is again subjected to similar pressure; which process is repeated until the mass has attained an adequate degree of density and solidity. Finally, it is rasped down again and well sifted, so that all the coarse particles are removed. As a rule, horn waste is worked up together with tortoise-shell waste, whereby greater strength is imparted to the product than if tortoise shell alone were used.

The fine powder is employed in the following manner: The powder is placed in layers between brass plates, several such layers being put into the press and the whole placed in boiling water, by which the mass is made solid and cohesive. The sheets are then subjected to further manufacturing processes; or finished objects can be stamped or pressed out of them at this stage, if the proper dies are available.

According to the following method, horn shavings can be so prepared that from the mass produced with their aid walking-cane and umbrella handles and a variety of other articles can be produced by casting in molds: Take 1 part unslaked lime, 0.5 of potash, 0.040 of tartaric acid, and 0.030 of salt; dissolve all in water and evaporate off one-third of the total water required for solution. Then throw in the rasped-down horn or lathe turnings and allow the mass to boil until it is just thick enough to pour into a mold. The mold, whether made of metal, wood, or burned clay, must be well coated with oil. If it is desired to have the horn mass colored, the color wished for is incorporated with the liquid horn mass, before it is poured into the mold.

The horn chips may also be boiled in a strong lye of lime and potash until the mixture is of the right consistency to pour into molds, and before pouring a suitable color can be mixed with it.

To produce from horn chips a consistent horn substance Herr Pathe lays them for an hour in a cold saturated aqueous solution of boric acid and a cold saturated solution of arsenious acid in dilute hydrochloric acid of 1.0 specific gravity, it being best to have the volume of boric acid solution twice as great as the arsenious acid. The vessel containing the horn substance gelatinized by this process is allowed to stand for an hour in a water bath of about 60 deg. C. and finally the horn substance is compressed firmly, by means of a pestle, into a closed iron form, heated to 120 deg. C., until all the liquid is expelled. The mass thus compressed, on cooling, forms solid plates of horny substance that can be worked like natural horn and that are remarkable for their plasticity and elasticity.—Dr. Theodor Koller, in "Verwertung von Abfallstoffen Aller Art."

THE DEVELOPMENT OF ARMORED WAR VESSELS.—X.

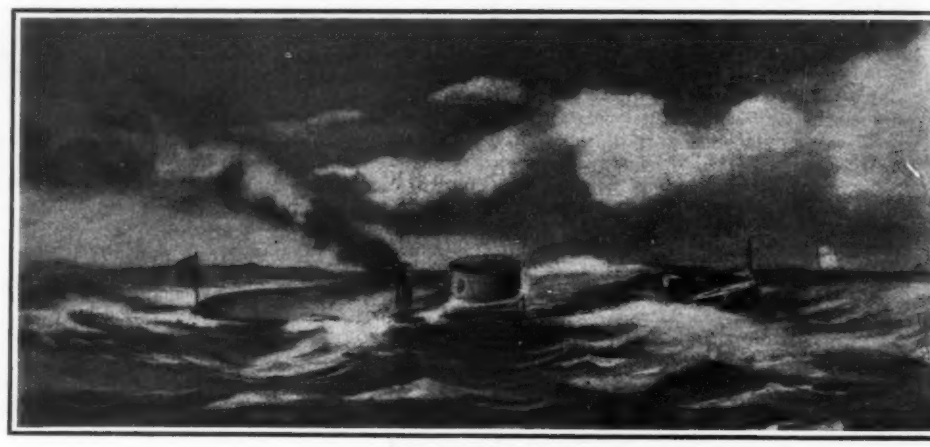
ARMOR PLATING IN THE UNITED STATES.

BY J. H. MORRISON.

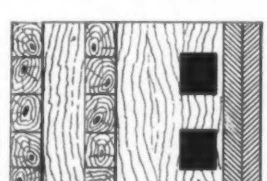
Continued from Supplement No. 1660, page 267.

The original "Monitor" had an armor on the hull of the vessel that was made up of five layers of 1-inch-thick iron plates tapering toward the bottom of three layers and backed by 30 inches of oak timber; while the turret was constructed of eight courses of 1-inch-thick iron plates. The largest of the side armor plates were 4 feet square, and the turret plates were 9 feet long and 40 inches wide. The "Passaic" class of monitors had side armor of the same thickness as the "Monitor," but having plates 5 feet in length and the same in width, with 39 inches of wood backing. The "Canonicus" class had five layers of 1-inch-thick plates, supported by two armor stringers let into 27 inches of wood backing. Their turrets had eleven layers of 1-inch plates. The "Miantonomah" and the "Monadnock," which were built of wood, were protected much like the "Canonicus" class of monitors. The "Puritan" and the "Dictator" had each six layers of 1-inch plates, and tapering on the sides, with 42 inches of wood backing. Their turrets were 15 inches thick, each composed of three courses, the outer of six layers of 1-inch plates, then 5 inches of iron slabs or blocks, and inside of these 4 inches of 1-inch plates. The "Kalamazoo" class were protected by a hull armor of a thickness of 6 inches, made up of two layers of 3-inch plates, backed by 30 inches of oak, and still further strengthened near the water line with three iron armor stringers each 8 inches square, let into the backing, and laid only a few inches apart. This was the most formidable armor carried on any of the monitors, though none of this class of vessels was completed at the close of the rebellion. This was denominated the "laminated" system of armor. The discussion between the advocates of the latter system of protection and those of the solid plate system was in this country very heated for a few years; as was the question: Is a timber backing to an iron armor of any advantage? For four or more years there were experiments carried on by the United States government, and by inventors, to arrive at some basis to start from on the question. It was subsequently found by experiments that the laminated armor had but about two-thirds of the defensive power, for the same thickness, as the solid plate.

An English authority, writing on the subject of iron-clad vessels at this time, said: "In the American navy we find what is called the 'laminated' system very largely adopted, which has proved to be decidedly the weakest. Experiments have shown that while a 4-inch solid plate would be an effective protection against a certain projectile, 6 inches of laminated armor would be easily penetrated. Another disadvantage in the laminated system is that it requires more fastenings than does a solid plate of equal thickness. . . . This system was adopted in the American navy in consequence of the difficulty of obtaining plates of the requisite thickness, for when the American ironclads were first called into existence there were not in that country any iron works capable of producing plates of so great thickness. However, attempts were made to compensate for this defect by introducing what were termed 'armor stringers,' portions of iron several inches in breadth and thickness, which extended the whole length of the ship behind the armor. But even this system did not create the resisting power of the solid plate." The "Dictator" and the "Puritan" had each three of these armor stringers, two above and one below the water line.



THE "MONITOR."



ARMOR STRINGERS.

The "Roanoke" was a wooden-hull steam frigate, a sister ship of the "Merrimac," that was cut down in 1862 and armored with hammered iron plates from the Franklin forge and the Paterson Iron Company. These plates were in size from 12 feet to 18 feet long and from 24 to 36 inches wide, $4\frac{1}{2}$ inches thick, and fitted together in place similar to the plating on the "New Ironsides." They extended 4 feet below the water line, nearly the whole length of the hull, and were backed by 30 inches of oak. Those at the ends were $3\frac{1}{2}$ inches thick. The turret plates for this vessel were bent to the proper curve in the hydraulic press, while in some of the other vessels the plates were heated and brought to the required shape with clamps and wooden beetles. There were three turrets, each of 21 feet diameter inside and 9 feet high, composed of eleven thicknesses of 1-inch rolled plates. The vessel was completed for service in February, 1863.

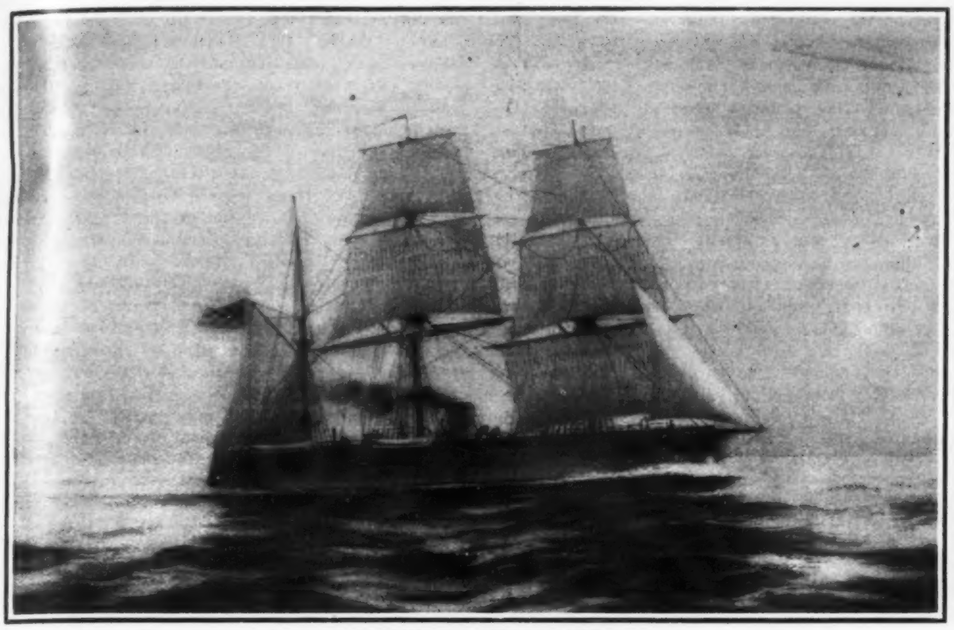
The "New Ironsides" was constructed in 1862, and the wooden hull plated with hammered iron $4\frac{1}{2}$ inches thick the whole length for 4 feet below and 3 feet above the load water line, terminating forward in a ram, and from that point to the spar deck the vessel was similarly plated for 170 feet admidships. The backing was of oak, and averaged about 20 inches in thickness. This armor was forged partly at the Bristol forge, and partly at Brown & Co.'s mill, and the plates were about 15 feet long by 28 inches wide, $4\frac{1}{2}$ inches thick, and weighed on an average 6,500 pounds each. They were tongued and grooved similar to a flooring board, the groove being 1 inch wide and $\frac{1}{2}$ inch deep. The fastenings were iron wood screws $1\frac{1}{2}$ inches by 17 inches long, and nine to a plate. This means of uniting adjoining plates was made use of prior to this on the British ironclad frigate "Warrior." There were heavy timber bulkheads between the berth and gun decks, and between the gun and spar decks, extending across the vessel both fore and aft, the distance between these bulkheads being $163\frac{1}{2}$ feet, or somewhat less than the length of the outside iron plating. These bulkheads above the gun deck were covered with diagonally laid iron bars 2 inches thick, in two courses, one overlying the other. In each bulkhead was a door of 5 inches solid plate sliding on rollers, and movable by rack and pinion. These protected bulkheads inclosed the gun deck, and proved an effectual barrier to a raking gun fire of the enemy. The designer of this vessel was B. H. Bartol, who at the time was the superintending engineer for Merrick & Sons, the contractors. The wooden hull was built by William Cramp & Sons under a sub-contract.

These bulkheads of the British frigate "Warrior" are thus described: "Just within the limits of her armor, and 205 feet apart, are placed two bulkheads

IRONCLAD STEAMER "ROANOKE."

or walls extending completely across the ship and formed almost as stoutly as her sides. The armor overlaps these bulkheads by one or two feet. They are plated externally with 4½-inch plates of iron, which extend down 9 feet below the water line in order that shot or shell entering the bow or stern may not pass them." This casemate protected the gun battery and machinery.

strips of yellow pine, each 1 inch thick and 4 inches wide, laid lengthwise of the vessel, their edges outboard, over the whole of which there were laid two courses of ⅝-inch iron plates. The strips of yellow pine were placed in the armor to keep the iron bars in position, until they were covered by the ⅝-inch iron plates, when the bars and plates were securely bolted together. The turrets were similarly constructed,



THE "NEW IRONSIDES."

The "Dunderberg" was also a wooden-hull vessel, built by William H. Webb, of New York. Her dimensions were 358 feet 8 inches between perpendiculars, 60 feet 8 inches breadth to outside of planking, and 22 feet 7½ inches depth of hold. She was plated on the hull to about 6 feet below the water line with forged iron plates 12 feet to 15 feet in length, 3 feet in width, 3½ inches thick, and screw-bolted to the wooden backing by 1¼-inch diameter bolts. The iron plates on the casemate were about 8 feet in length, 28 inches wide, 4½ inches thick, and secured in the same manner as the plates on the hull of the vessel. All the plates were laid vertically, both on the hull and the casemate. Those on the hull were mostly laid at an angle of 35 deg., and those on the casemate at an angle of 55 deg. The timber backing at the gun deck was 36 inches, and that at the water line 48 inches. These armor plates were forged by Brown & Co., of Pittsburg, Pa. The vessel was sold in 1867 by her builder to the French government, and her name changed to "Rochambeau." The same builder constructed for the Italian navy two wooden-hull ironclad frigates in 1863 named " Re di Italia" and "Re di Portogalla." These vessels were each, 283x55x33.7 feet, and were armored with hammered iron plates made by the Wayne Iron Company, and the Franklin forge, for 5½ feet below the load water line, and 10 feet above the water line. The lower courses of the iron armor were 4¾ inches thick, and the upper courses 4½ inches thick, and extended the whole length of the vessel from stem to stern.

There were constructed for the Union navy the "Keokuk" and the "Galena," each having an iron armor peculiar to itself. The former was built in 1862 at New York by Jerome S. Underhill for Charles W. Whitney, the contractor, who was at the time the New York agent for the Abbott Iron Company, that furnished the heavy plate iron for the monitors. The "Keokuk" was a two-turret ram, having an iron hull of ½-inch plate, and dimensions of 159.6x36x13.6 feet and draft of 9 feet. She had a turtle-back form with sloping sides. The peculiarity of her armor consisted in its being formed of alternating bars of iron and but had an additional course of ½-inch iron plates. There was a strongly built ram 3½ inches thick at front and foot, and 5 feet long. The vessel was finished for commission in January, 1863.

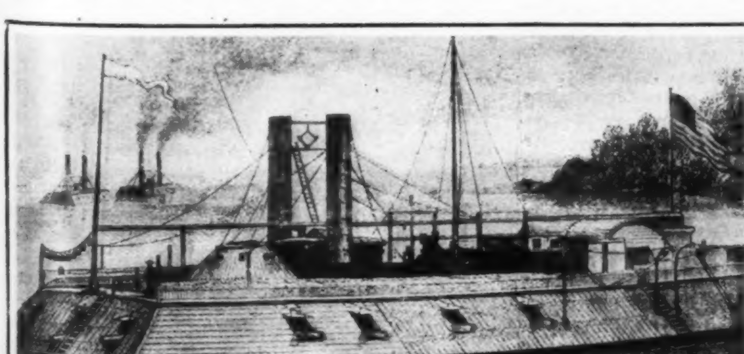
The "Galena" was built in the same year at Mystic, Conn., with a wooden hull, having a length of 208 feet, 36 feet beam, and 12 feet 6 inches deep. Her sides above the water line "tumbled home" at an angle of 40 deg. The armor was applied in the form of iron bars 24 feet in length and 3 inches wide, these successively overlapping each other by one-third of their width, in a peculiar manner, and were fastened to the wooden frame by screw bolts, while over this framework of iron bars was an additional course of 1-inch iron plating.

When the "Keokuk" and the "Galena" were subjected to the actual service of warfare the systems used in the application of their armor plating were then proved to be defective.

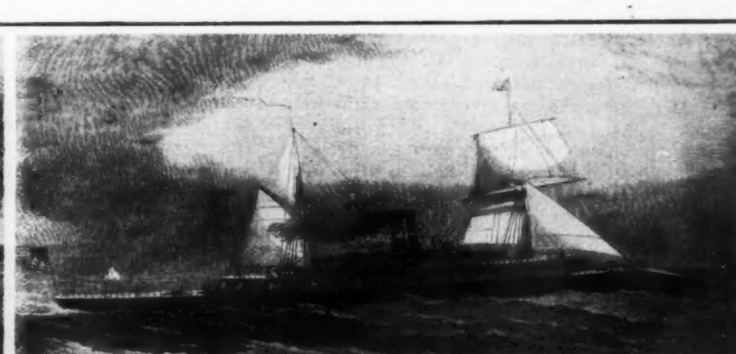
There were plans made in 1863 for twenty monitors of 614 tons each, to be of light draft, for service on the southern rivers. Fifteen of these vessels were constructed (or more properly stated, partially so) on the Atlantic coast and five in the Western States. They were to have a draft of 6½ feet, with a freeboard amidships when equipped for service of 15 inches and a speed of seven miles an hour. Many changes were made during the progress of construction, and when the first of these vessels, the "Chimo," was launched in May, 1864, at Boston, it was found that she was drawing several inches in excess of the estimated draft of the vessels, which later caused a suspension of work on the other vessels. They were found to be defective in draft of water, and subsequently in speed, making but three and a half or four miles an hour. Instead of being some 15 inches out of water when fully completed and equipped, as was the original design, it was found that they would barely float, their decks being awash with the water. The increased draft was caused by reason of a miscalculation of the weights of material, and in consequence of the additions and alterations made in the plans after the contracts were entered into. The use of green timber, for none other could then be obtained, where the weight of seasoned timber had been estimated upon in the calculation of weights, and the partial use of heavier iron plate than contracted for, accounted for part of the extra weight. These vessels were designed and built under a special bureau in the Navy Department, and there was at the time a want of harmony existing between the bureaus of construction in the department, that would produce the best results. This was the first clash between the constructors of iron and of wooden vessels in the navy, after the building of Stevens battery, and it was many years later before the advocates of iron-hull vessels in our navy could say they had a foothold. Fifteen of these vessels were subsequently altered by building up their sides 22 inches, and five were altered into torpedo boats, so called, at a very large expense. They were not finished until after all use for them had passed. The five built in the West, with three of a greater tonnage built in the West also, were sold at auction in 1874 for $69,075, their total cost having been $4,147,267. Two of these larger monitors were the "Winnebago" and the "Chickasaw." Two of them, the "Catawba" and the "Oneota," were purchased in 1868 by their builders, Swift & Co., of Cincinnati, who sold them to the Peruvian government just at the close of the Chilian-Peruvian war. The sale of these vessels caused considerable stir in marine and political circles in the country at the time, as it was expected trouble would ensue between Chili and this country from the sale of these vessels, but the war ended just previous to delivery of the vessels at Havana, Cuba.

The original designs of some of these ironclad vessels built in the West may be seen from a description given by Capt. J. B. Eads of some of those he contracted for: "In the course of a few days I presented to the Navy Department the plans for the 'Osage' and the 'Neosho.' These vessels, according to my recollection, were about 45 feet beam on deck, their sides slanting outward, and the tops of the gunwales rising only about 6 inches above the surface of the water so as to leave very little space to be covered with the plating, which extended 2½ feet down under water on these slanting sides. The deck of the vessel, rising 6 inches above the water, curved upward about 4 feet higher at the center and this was covered all over with iron an inch thick. The plating on the sides was 2½ inches thick. Each vessel had a rotating turret, carrying two 11-inch guns, the turret being either 6 or 8 inches thick, but extending only a few feet above the deck of the vessel. I was very anxious to construct these turrets after a plan which I had devised, quite different from the Ericsson or Cole system, and in which the guns should be operated by steam; but within a month after the engagement at Fort Donelson, the memorable contest between the "Merrimac" and the 'Monitor' occurred, whereupon the Navy Department insisted on Ericsson turrets being placed on these two vessels. At the same time the department was anxious to have four larger vessels for operations on the lower Mississippi River which should have two turrets each, and it consented that I should place one of my turrets on each of two of these vessels, the 'Chickasaw' and the 'Milwaukee' (at my own risk), to be replaced with Ericsson's in case of failure. These were the first turrets in which the guns were manipulated by steam, and they were fired every forty-five seconds. The 'Osage' and the 'Neosho' with their armament, stores, and everything on board, drew only 3½ feet of water, and steamed about nine miles an hour. While perfecting those plans I prepared the designs for the larger vessels, the 'Chickasaw,' the 'Milwaukee,' the 'Winnebago,' and the 'Kickapoo.'"

There was submitted to the Union Navy Department about this time the design of a new system of defensive armor for naval vessels, that was radically different from any other system of armor protection brought to their notice, or in use at the time on vessels of war. The principle involved in this system consisted in arresting by gradual resistance the shot that struck the armor. This was to be effected by placing an iron plate at an intermediate point of the whole armor, and having an outer elastic coating to



EADS WESTERN RIVER IRONCLAD GUNBOAT.



STEAM RAM AND FLOATING BATTERY "DUNDERBERG."

receive the blow from the shot. Otherwise, there was to be an inner layer of heavy iron between two courses of timber. This system was subjected to a few experiments, but like many others at the time the practical trials of the system soon developed its many weak points.

The only armored vessel that was built in this country at the time, having an armor with a course of wood between courses of iron, was the "Onondago," built in 1863 by Thomas F. Rowland for George W. Quintard, contractor with the United States Navy Department. This vessel was a two-turret monitor with the exception of the forward overhang that was such an objection at the time to most naval officers. The armor of the hull of the vessel was radically different from any that had been applied on that type of vessel. It consisted of an inner course of 4½-inch hammered iron, about 54 inches deep, and carried all around the vessel, and this faced with locust timber 13 inches thick; outside of this timber was a course of 1-inch-thick iron plates. The turrets were 21 feet inside diameter, 9 feet high and 12 inches thick. The walls of these structures consisted of six courses of 1-inch iron plates inside, outside of which was a course of 4-inch forged-iron plate, and again outside of these were two more courses of 1-inch iron plates. This vessel was sold to the French republic about the time that the "Dunderberg" was disposed of.

There were seven western river ironclads built by James B. Eads & Co. (Union Marine Iron Works) at St. Louis in 1861, from plans made at Washington under direction of Capt. John Rodgers, U. S. N. Three of these wooden hulls were constructed at Mound City, Ill. The forward end of the casemate of these vessels was plated with rolled iron that was 13 inches wide, 2½ inches thick, and from 8 feet to 11 feet long, and laid at an angle of 45 deg., with a backing of 24 inches of oak timber. The rest of the casemate was unprotected except for about 40 feet abreast of the engines and boilers, where there was an iron armor of the same thickness as on the forward end of the casemate, but without any oak or timber backing. The pilot house on the forward side had 2½-inch iron armor, and on the after side 1½-inch iron armor. All these plates were rabbeted on the edges to make a more perfect joint, and fastened with 1¼-inch countersunk head bolts, having nuts and washers. The original plans for construction provided for armor plate protection to all exposed surfaces, and extending four feet below the water line, but it was found on closer calculations of the proposed weights to be carried that the vessels would not float when fitted for service, and it was finally decided to armor the vessels only in front and to cover the machinery. These vessels were named "St. Louis," afterward "Baron De Kalb"; "Carondelet," "Mound City," "Pittsburg," "Cairo," "Cincinnati," and "Louisville." There was also the "Benton," a reconstructed vessel that was in the same fleet, that was plated about the same as those mentioned. There was also the "Essex," a reconstructed vessel, that had a compound armor on the casemate. It was formed by laying on the wooden backing a course of vulcanized rubber 1 inch thick, covered on the forward part of the casemate by iron 1 inch thick, and on the sides of the casemate with iron ¾ inch thick, and bolted to the backing. This plate iron was made by the Laclede Iron Company of St. Louis, Mo. There were at a later date two other gunboats on the western rivers that were similarly plated, the "Lafayette" and the "Choctaw." The hull of the "Essex" was divided into fifteen water-tight compartments, as were those previously built. This sheet rubber was subsequently found to be of no value whatever for the purpose it was intended. The "St. Louis," the first of this fleet, was ready for service on December 12, 1861, six weeks before the "Monitor" was launched. These vessels were built by order of the Quartermaster's Bureau of the War Department, but a few months after being placed in service were transferred to the Navy Department. In 1865 those afloat were sold to parties who broke them up.

It was found in the service to which all these ironclads were subjected, that a well-placed large shot seldom failed to weaken some of the fastenings of the iron armor having an elastic backing. Government experiments at the same period had also shown that the more unyielding the backing, the less damage was done to the fastenings of the armor.

(To be continued.)

DIAMOND CUTTING IN AMSTERDAM.

A CURIOUS CRAFT.

Among the many industries of Amsterdam that of diamond cutting has long been an important one. Since the fifteenth century it has been extensively carried on, and at the present time no fewer than sixty firms are registered in Amsterdam as diamond cutting or diamond polishing companies. Some of the firms restrict themselves entirely to one process, that of diamond polishing, while others carry out the whole of the three processes—diamond splitting, diamond cutting, and diamond polishing. According to the American consul at Amsterdam, in one of these typical complete factories 90 per cent of all the many thousands of rough uncut diamonds received every year come from South Africa, principally from Kimberley. It gives some idea of the importance of this industry in Amsterdam to realize that 400,000 diamonds were cut and polished in this factory in one year alone, and that 300 to 500 men are daily employed in the different workshops by this one company, which also employs about twenty women, who are intrusted with the very important work of diamond cutting. Although the firm was established in 1843, it was not until 1875 that women were employed in the factory, but so satisfactory was the experiment that now nearly the entire work of diamond cutting is done by them, thousands of diamonds passing annually through their hands.

The first of the three processes through which the rough, uncut diamond has to pass is that of splitting the stone. About twelve men are employed in this task, which is all done by hand without the aid of machinery. It is not a lengthy process unless the stone contains a great many flaws, for an ordinary diamond weighing about 10 carats can generally be split in fifteen minutes. The object is to divide the rough, uncut diamond (containing flaws) into several pure, flawless stones, and in order to do this strong pressure is exerted on the weak spots (caused by flaws) by means of a diamond-tipped tool, which is held in the right hand. It is an old and well recognized principle that "nothing but a diamond will cut a diamond." In the left hand is held a curiously-shaped little frame into which the rough diamond now to be split has been firmly fixed. Great pressure is then used on the weak spot, and in a few moments the diamond splits into two portions. Should there be any more flaws in either of these sections the process is repeated until several pure flawless diamonds lie on the rough wooden tables of the workmen, ready now for the second process, that of cutting. This process, like the first, is almost entirely performed by hand in the factory referred to, but with one striking difference—the work is done by women and girls instead of men. Only in the case of very hard, difficult stones is machinery necessary, and then men are employed to use it. The work of diamond cutting is a delicate and difficult task, very trying to the eyes, too, for some of the diamonds are so minute that 400 of them or more may weigh only half a carat. Each worker is responsible for the packet of diamonds she receives at intervals from the forewoman, and if by accident she loses one of the precious stones she has either to find it again or refund its value. The tools employed in diamond cutting are very similar in appearance to those used in the first process, that of diamond splitting. In both cases diamonds are used as knives after having been firmly fixed into the tip of pear-shaped tools. The women hold in the left hand the rough diamond they wish to cut, which has also been firmly fixed into a wooden frame. Little jets of gas are always kept burning on the various tables ready to be used at any moment when melted wax is necessary. The only real difference in the two processes of diamond splitting and diamond cutting lies in the fact that whereas the men who split the diamonds use pressure on one spot only (where the flaw occurs) the women devote themselves to rounding the whole stone, and carefully cutting off all angles to be seen on its surface by means of the sharp diamonds they hold in their right hands. Occasionally they have very large diamonds to cut, which take a great deal of time, but an ordinary stone weighing about 10 carats would not take so very long. When the diamond has been sufficiently cut and rounded, it is then ready for the third and last process, that of polishing. This work requires a great deal of time and skill, and is performed entirely by machinery, a steam engine supplying the motive power for all the iron disks. The process consists in giving to the rounded diamonds what is termed, in technical language, their necessary "sides." All diamonds are divided into two classes, "brilliants" and "roses," although the only real difference between them lies in the number of "sides" they individually possess after having been polished in one of the many diamond factories. A "brilliant" must possess fifty-eight "sides" (a few years ago the lowest number was sixty-four, for there are fashions in diamond cutting), but a rose need only possess twenty-four "sides." Another (though slight) difference between them is, that a brilliant is pointed at both ends, while a "rose" diamond has one end flattened and the other pointed. When the diamond is ready to be polished it has first to be soldered into a pear-shaped frame made of zinc and then dipped into a preparation of oil and diamond dust before being fastened, with three others, into a strong frame placed in close proximity to an iron wheel. This little disk is then set in motion, by connecting it with the great engine, and the wheel immediately turns at the rate of 2,000 revolutions to the minute. As it revolves, the four diamonds set in the adjacent frame are gradually polished by means of the friction produced on their surface by the particles of diamond dust still adhering to the oil into which they had been previously dipped. Only one portion of a diamond can be polished at once, and consequently, when this part has been dealt with, the stone has to be re-soldered, so that another portion of its surface may be subjected to the friction of the wheel. The process of re-soldering takes place about twenty times in the case of every brilliant, before it can be considered to be thoroughly polished, and to have acquired all the necessary fifty-eight "sides." The "rose" diamond, with its smaller complement of twenty-four "sides," needs to be re-soldered only about six times.

During the last year the press, both in South Africa and Europe, has devoted considerable attention to the discussion of projects having in view the establishment of a diamond polishing industry in Cape Town, Johannesburg, and other places, but such projects are not regarded seriously in Amsterdam. Wages paid in the diamond industry at Amsterdam are estimated to have amounted to $8,500,000 in 1905.—Journal of the Society of Arts.

THE ELECTRODEPOSITION OF TIN.

The electrodeposition of tin is not practised to any great extent, but there are occasions where it is desired, and platers have difficulty in carrying it out. While a simple chloride of tin solution will deposit tin by means of the electric current, the deposit is spongy and dark colored. The tinning of copper beer steins is one of the recent demands for the electrodeposition of tin. Another is the tinning of brass and copper goods previous to japanning. The japan gives a better color on the brass and copper when tinned. The best bath for the electrodeposition of tin is that of Roseleur, in which the pyrophosphate of soda is used. The bath is made up as follows:

Water	5	gallons.
Pyrophosphate of soda	6	ounces.
Chloride of tin	¾	ounce.

The pyrophosphate of soda is dissolved in a small quantity of the water, and the chloride of tin (tin salts) is dissolved in another portion of the water (just enough to dissolve it), and then the two are mixed and added to the main portion of the water. The solution should be clear and slightly yellow when properly made. A strong current is needed for the deposition of the tin, and from 4 to 6 volts are necessary to force it through. The bath should be worked warm. The tin deposits in a dead, white condition resembling silver. Burnishing or scratch-brushing brings out the luster. A scratch-brushed surface is that which is usually employed. A note about the use of pyrophosphate of soda may be of interest. The pyrophosphate of soda is not the same as phosphate of soda, although made from the latter. It is made by melting the dried phosphate of soda in a crucible, so that an equivalent of combined water is lost, and the substance becomes basic. Pyrophosphate of soda has an alkaline reaction, and is not as soluble in water as the ordinary phosphate of soda. The phosphate of soda will not answer in making up this tinning bath. —The Brass World.

It is reported from Chili that the Central Railway Company of Guatemala is changing the fuel of its locomotives from coal to oil—raw petroleum. It is estimated that a maximum of 70,000 barrels a year will be used. Guatemala produces neither coal nor oil, and the cost of importing is approximately the same; but, owing to the greater heat of the oil fires and the greater facility in management, it is hoped to save 40 per cent.

The Boletin Oficial of Argentine for August contains a copy of a decree which authorizes the Buenos Ayres-Pacific Railway Company to construct a river wall on the La Plata, and a high-level railway through the town, with a station in Maypú Street, together with the necessary bridges.

FLOATING CRANES.

A REVIEW OF HOISTING DEVICES.

FLOATING cranes are indispensable for the lifting of heavy masses, particularly in connection with shipbuilding. The earliest floating cranes, constructed some forty years ago, were built on the model of the stationary gallows or A crane of the period, the crane hoisting engine. This improvement made it possible to lift objects from the float itself, though only from between the feet of the crane, at the extreme bow, as the crane could not be drawn back beyond a vertical position without falling. The range of action was by bevel gearing. (Fig. 11.) In this form the nut is set in the center of a bevel wheel, which moves around the fixed bevel driving wheel according to the inclination of the third leg. The rails are eliminated and the friction is greatly diminished. This arrangement

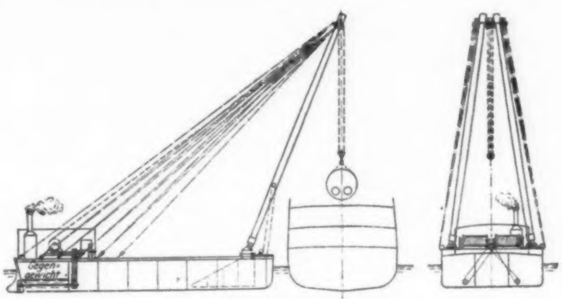


FIG. 1.—GALLOWS CRANE WITH FIXED STAYS.

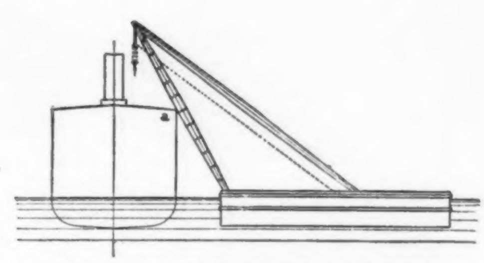


FIG. 2.—LIMIT OF APPROACH OF STRAIGHT-LEGGED CRANES.

overhanging the bow of the rectangular float and being stayed by ropes attached to its sides. At the stern were placed the hoisting engine, with its boiler and furnace, a large water tank and a steam pump by which the tank could be filled and emptied, so as to keep the float level under all loads (Fig. 1). The float was provided either with screws for self-propulsion or with capstans which hauled ropes attached to vessels or the shore. Various improvements which from time to time were made in this primitive contrivance are illustrated in the succeeding diagrams.

Fig. 3 shows a crane with variable overhang, in which the fixed stays are replaced by a rope passing over pulley blades and a second winch, driven by the

increased by substituting for the stay rope a third leg and attaching its foot to a nut traveling on a long horizontal screw which was turned by the engine. (Fig. 4.)

But as this screw could not sustain the thrust and pull exerted by the third leg, the foot was inclosed by heavy guide rails, between which it moved with great friction. Both the friction and the space occupied by the screw and guide rails were considerably diminished by placing them in line with the third leg, in its advanced position, and supporting them by a massive frame. (Fig. 5.) The same objects were accomplished much more satisfactorily, however, by attaching the screw rigidly to the leg and turning the nut

was first adopted in a crane constructed for the Austrian navy at Pola. In still another form, the screw is rigidly attached to the bevel wheel and turns with it, while the nut is borne on the end of the third leg. (Fig. 13.) The nut and the third foot are sometimes supported by a bolster over which they glide, as indicated by the dotted lines, but the bolster only occupies space and introduces friction and is wholly unnecessary.

Many cranes of this type are still made for the German and other navies and shipbuilders. The legs are constructed either in tubular or in truss form, the latter construction (Fig. 21) being employed for large cranes

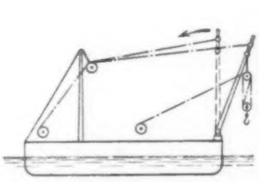


FIG. 3.—GALLOWS CRANE RAISED AND LOWERED BY A WINCH.

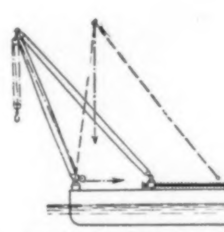


FIG. 4.—EARLIEST TRIPOD CRANE WITH HORIZONTAL SCREW.

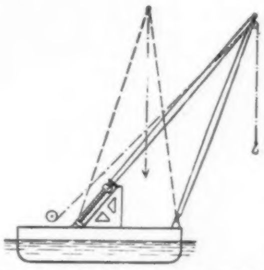


FIG. 5.—TRIPOD CRANE WITH INCLINED SCREW.

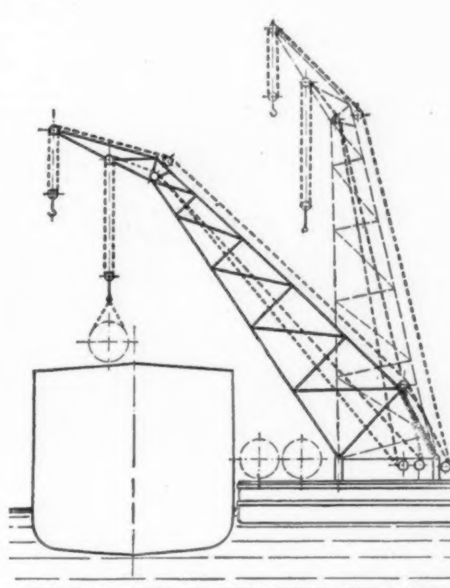


FIG. 6.—BENT TOWER CRANE.

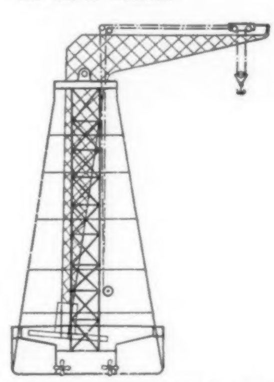


FIG. 7.—OLD ROTARY CRANE AT LONDON DOCKS.

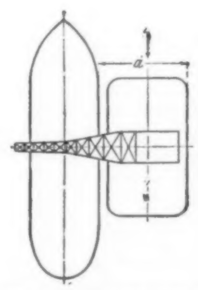


FIG. 8.—LIMIT OF APPROACH AND WIDTH OF CHANNEL FOR TOWER CRANE PROJECTING FROM SIDE OF FLOAT.

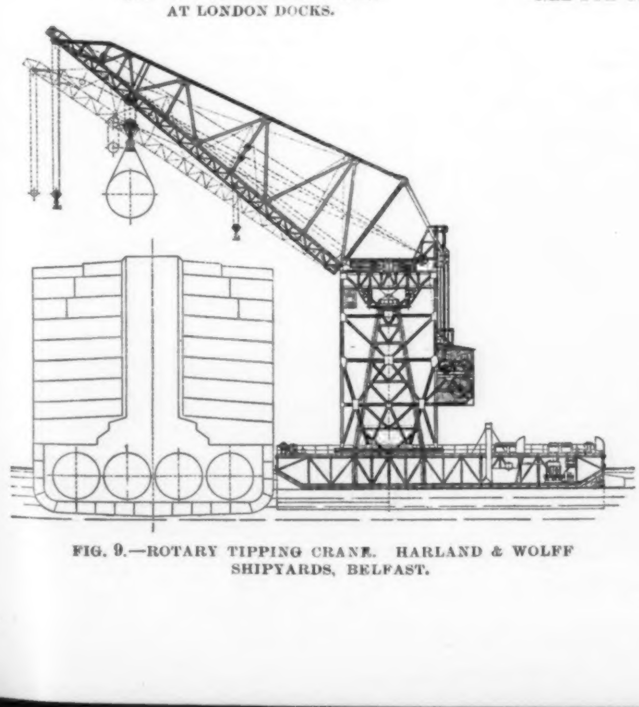


FIG. 9.—ROTARY TIPPING CRANE. HARLAND & WOLFF SHIPYARDS, BELFAST.

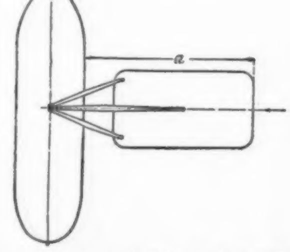


FIG. 10.—LIMIT OF APPROACH AND WIDTH OF CHANNEL FOR TRIPOD CRANE PROJECTING FROM BOW OF FLOAT.

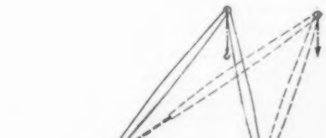


FIG. 11.—TRIPOD CRANE WITH SCREW ON THIRD LEG.

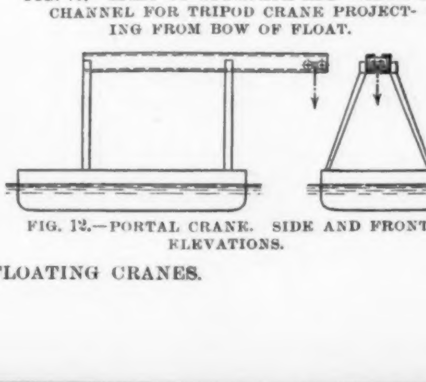


FIG. 12.—PORTAL CRANE. SIDE AND FRONT ELEVATIONS.

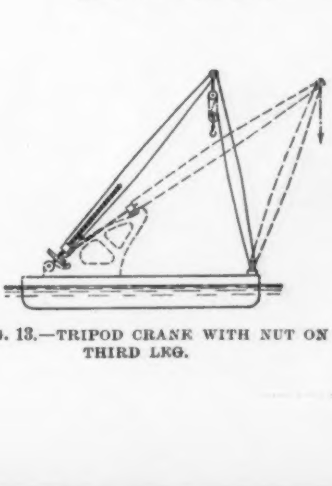


FIG. 13.—TRIPOD CRANE WITH NUT ON THIRD LEG.

FLOATING CRANES.

But all cranes with three straight legs, whether extensible or not, have two serious defects. The length of objects which they can handle directly and in the usual manner, is limited to the distance between the two front feet of the crane, between which the object must be swung. The mounting of masts and smokestacks is thus rendered very difficult. Again, the maximum overhang of the crane can rarely be employed, owing to the interference of the ship's side can be lifted from the former to the latter, as indicated in Fig. 6. The tower turns on its front edge as its rear is raised or lowered by screws and nuts arranged on the principle illustrated by Fig. 11. The tower construction is less costly than the tripod construction, and is especially adapted for large cranes. The Duisburg Company has built several of 100 tons, and one (for a Tyne shipbuilding firm) of 140 tons capacity.

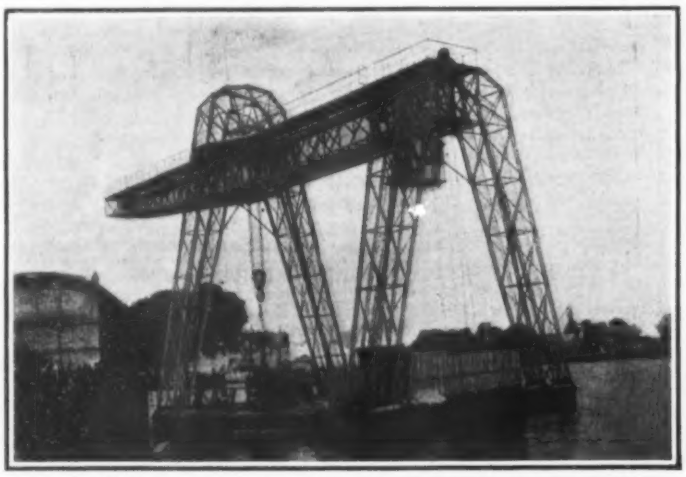


FIG. 14.—60-TON PORTAL CRANE BUILT BY DUISBURG MACHINE WORKS FOR A DANZIG SHIPYARD.

with the inclined legs of the crane. (Fig. 2.) The latter objection is more serious in floating cranes than in cranes mounted on quays at some distance above the water level.

In a crane constructed for the harbor of Riga (Fig. 22) these inconveniences are obviated by bending the front legs at an obtuse angle. The third leg is jointed in the middle and the foot rests on a carriage which is moved on a bolster by a screw turned by bevel gearing. (Figs. 15 and 16.) The float of this crane carries also a rotary crane with a rigid arm, for weights of less than 7 tons.

The Duisburg Machine Company has recently introduced two notable improvements in floating cranes, substituting for the tripod a single bent, pyramidal tower of lattice work, and making the plane of motion of the crane perpendicular to the axis of the float. (Figs. 10, 6, and 8.) Thus the width of the channel required for the float is diminished, the float can be brought close to the ship, and objects of any size

The erection of one of these great tower cranes upon its float is a very interesting operation. The crane having been completely assembled in a horizontal position, with its base projecting over the water, the float is brought under the base and the journals are adjusted to their bearings. (Fig. 18.) The top of the tower is then raised by a stationary crane on the quay until the screws at the back of the base enter the corresponding nuts. (Fig. 17.) Fig. 19 shows a floating crane of this type, of 100 tons working capacity, being tested with a weight of 130 tons. Instead of a single bend, the tower may have several bends or a curved form adapted to the special purpose for which it is designed.

Rotary floating cranes have usually been employed only for small loads. Fig. 20 shows a modern 30-ton rotary crane, built by the Duisburg Company for the Hamburg-American Line. A diagram of an old rotary floating crane used in the London docks is given in Fig. 7.

Now, however, very large floating cranes capable of rotation through an entire circle are coming into use. The Beurather Machine Company is building two such cranes, one for the Japanese navy, the other for Harland & Wolff, the Belfast shipbuilders. (Fig. 9.) These cranes, in addition to rotating about a vertical axis, tip about a horizontal axis, like the cranes already described. The Japanese crane is designed to raise 110 tons, with an extension of 59 feet measured horizontally from the axis of rotation. The English crane is still more powerful, lifting 150 tons 100 feet from the axis of rotation, or 57 feet from the side of the float. With smaller loads the extension can be considerably increased. Weights of 10 and 20 tons can also be lowered from the extreme ends of the arms, at a considerable distance beyond the points of attachment for very heavy loads. The Japanese crane is set in the middle of a ship-shaped float, the English crane near one end of a rectangular float, at the other end of which a compartment filled with concrete serves both as a counterpoise and as a place of deposit for heavy loads.

The portal or gate-shaped type, with a unilateral or bilateral cantilever and traveler (Fig. 12) was first adopted in a floating crane constructed for the New York navy yard by the Brown Hoisting Machinery Company, of Cleveland, Ohio. Many cranes of this type have since been built. Usually, each of the piers that support the horizontal beam, or cantilever, consists of two inclined legs, joined at the top and spreading below. The load is hauled up from the float, between the front and rear pairs of legs, and then carried forward between the front legs by the movement of the traveler along the beam. Hence, the size of the object lifted is limited by the distance between the front legs, as it is with the tripod crane, and as this distance decreases in proportion to the elevation of the load, when the legs are inclined, it is sometimes preferable to make the front legs, at least, vertical, and connect them by a beam which supports the main beam or cantilever.

The crane in the New York navy yard is designed for a maximum load of 100 tons. Four inclined legs, of lattice construction, support a double cantilever truss 210 feet long, which projects beyond the float at both ends and carries the traveler on its bottom chord. The float is 98 feet long, 26 feet wide, and 11 feet deep. A notable feature of this floating crane is a counterpoise moved along the deck by a small steam engine to balance the moving load.

Three floating cranes of the portal type are in use at Trieste, Austria. In two of these cranes, of 25 tons capacity, the legs are welded steel tubes 24 inches in diameter, stiffened by bracing. The traveler has two

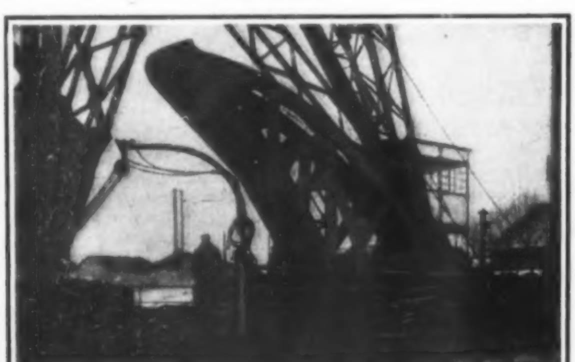


FIG. 15.—BOLSTER OF RIGA CRANE.

FIG. 16.—BEVEL GEAR OF RIGA CRANE.

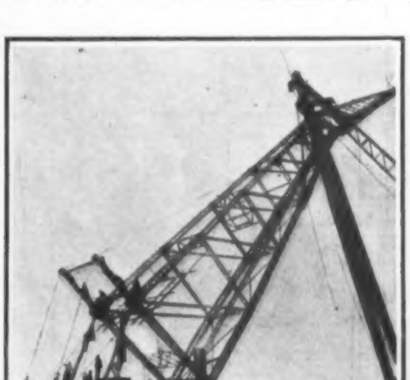


FIG. 17.—ERECTING TOWER CRANE.

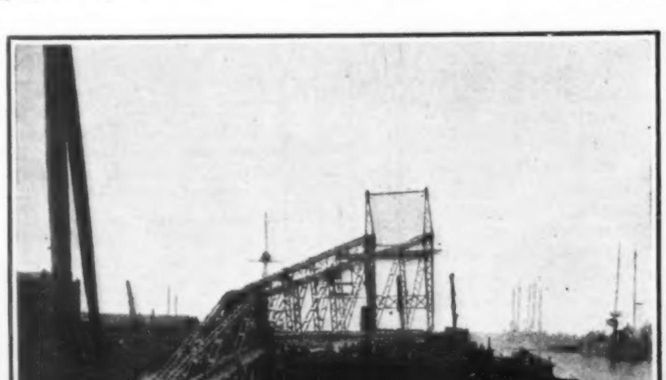


FIG. 18.—BRINGING FLOAT UNDER FOOT OF TOWER CRANE.

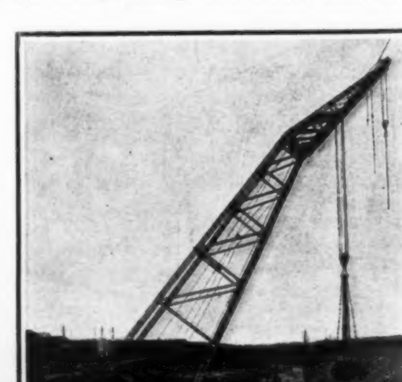


FIG. 19.—100 TON TOWER CRANE BUILT BY DUISBURG MACHINE WORKS.

FLOATING CRANES.

four-wheeled trucks and runs on two rails which rest on the bottom chord of the cantilever at a height of 69 feet above the deck of the float. The legs of the third crane, which is designed for greater loads, are of lattice construction.

A 60-ton crane constructed by the Duisburg works for a Danzig shipbuilder is shown in Fig. 14. The feet are placed at the corners of the float in order to increase the space available for the deposition of loads. The engine and boiler are placed between the after legs. The float has no screw propeller, but is moved by ropes and capstans driven by the engine, by means of belts and shafts under the deck. There are four capstans, one near each foot of the crane. The legs and cantilever are trusses and the traveler runs on the bottom chord. Equilibrium is maintained by means of three adjoining water compartments, which can be filled and emptied by a steam jet pump placed below the deck. With 88 tons of water ballast aboard and the maximum load of 60 tons suspended from either end of the cantilever, the inclination of the deck is 4½ degrees. The entire length of the cantilever is about 85 feet, and the long arm projects 33 feet beyond the float.

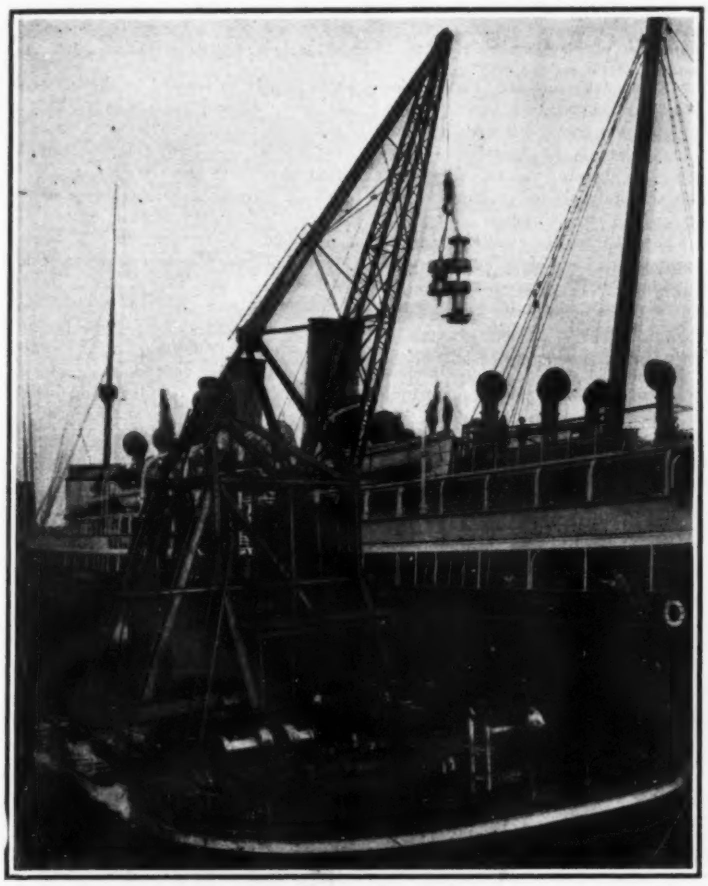


FIG. 20.—30-TON ROTARY TOWER CRANE BUILT BY DUISBURG MACHINE WORKS FOR HAMBURG-AMERICAN LINE.

All the cranes above described are operated by steam. This is the general practice with floating cranes, in which the electric drive, now so commonly employed in other hoisting apparatus, is hardly practicable. In some of the newest and largest floating cranes, however, the winches distributed over the great structure are driven by electric motors which are fed by current generated on the float, as the increased convenience of operation outweighs the loss of power involved in the conversion. Some floating cranes, also, have small dynamos for electric lighting.—Translated for the SCIENTIFIC AMERICAN SUPPLEMENT from Prometheus.

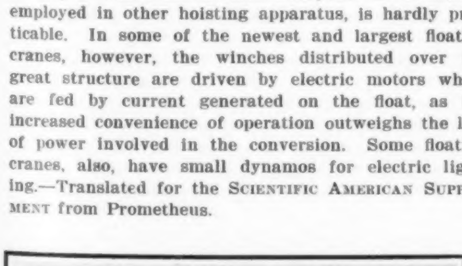


FIG. 21.—80-TON CRANE AT RIO DE JANEIRO. MADE IN GERMANY.

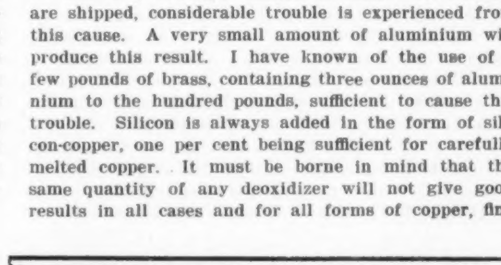


FIG. 22.—CRANE WITH BENT LEGS, RIGA.

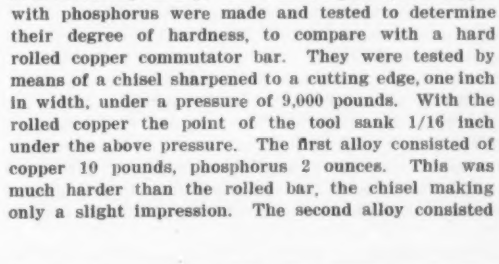


FIG. 23.—25-TON PORTAL CRANE AT TRIESTE.

FLOATING CRANES.

CASTING COPPER.

By C. VICKERS.

THERE are many methods of making solid copper castings. In all of them, however, some other metal or metalloid is added to the copper to deoxidize it, or expel the gases held in solution by the molten metal. Among the metals so used are zinc, aluminium, silicon, magnesium, manganese, sodium, and iron. Phosphorus, which is also used, is a metalloid. When phosphor-tin is used, it is the phosphorus which is the active agent in removing the gas from the copper, tin having no value as a deoxidizer. All of the agents above mentioned have some unpleasant influence upon copper which affects its casting qualities. Zinc must be added in such quantities, to give the required result, that the resulting metal is really an alloy, and the natural red color of the copper assumes a lighter tint. Aluminium introduces shrinkage difficulties. The castings will draw at the gates, unless heavily fed by the sprue, and crack in the corners, if not held up by feeders. Sometimes zinc and aluminium are used together, but it is a treacherous combination, because of concealed cracks. Such castings as copper studs for switchboard work will crack at the juncture of the head, and a light blow will often separate the same; as this is not always discovered before the castings are shipped, considerable trouble is experienced from this cause. A very small amount of aluminium will produce this result. I have known of the use of a few pounds of brass, containing three ounces of aluminium to the hundred pounds, sufficient to cause this trouble. Silicon is always added in the form of silicon-copper, one per cent being sufficient for carefully melted copper. It must be borne in mind that the same quantity of any deoxidizer will not give good results in all cases and for all forms of copper, fine wire requiring the largest amount of any deoxidizer and good ingot copper the least. I have often found that a smaller quantity of silicon-copper than one per cent will do the work. The least possible quantity should be used, otherwise the castings will be drossy. Silicon produces fine red copper castings; while the metal does not appear fluid, it runs exceedingly well. The castings must be heavily fed in massive places, and all corners be well rounded, to avoid cracks. Silicon-copper castings are very soft, like annealed wire, which unfits them for some purposes. When tin is used to stiffen such castings, they cease to be copper and become a gun metal. Antimony is more effective than tin as a stiffener, and makes the copper rather short, but has no appreciable effect on its red color. An alloy of one per cent of silicon-copper, two per cent of antimony, and ninety-seven per cent of copper, is quite stiff and very sonorous. Sodium is added to copper in a roundabout way, as metallic sodium must be used with caution in making alloys, on account of the violent reaction. It possesses no advantage over other metals used for the same purpose. Iron may be considered a strange thing to add to copper to make solid castings. It will do the work, however. It should be added by means of yellow prussiate of potash, which is thrown onto the molten copper and allowed to fuse. It should then be stirred in. The resulting castings are soft, ductile, solid, and of a good color.

For ordinary copper castings, which should be tolerably stiff and may be machined well, and where such qualities as high electrical conductivity are immaterial, the most economical deoxidizer that can be used is zinc. For copper scrap, melted under ordinary shop conditions, use six per cent. The color of such castings is such that they readily pass as copper; they run smooth and clean, and are free from excessive shrinkage, draw holes, and such troubles. The addition of phosphorus is unnecessary, unless there are signs of mushiness, which will not happen provided charcoal is liberally used in melting. Phosphorus and zinc together in copper cause trouble from dirt, so keep out the phosphorus if possible. To reduce mush—that is, oxidized or burnt copper—use two ounces of phosphorus to the hundred pounds of copper, stir the molten metal thoroughly, cover with charcoal, and leave the crucible in the fire until the mush is reduced, when the metal will appear bright and lively under its cover of charcoal.

Phosphor-tin is a good, reliable article to use to add to copper, but it is more expensive than zinc. Phosphorus can be added in any quantity to produce solid copper castings, as it does not affect the color of the metal. By its use copper can be so hardened that tools will not touch it. It is difficult to secure clean castings on account of the slag, which is very fluid and lively, and is constantly rising to the surface of the copper in little globules, which amalgamate around the sides of the crucible and are difficult to keep out of the mold. These little globules of sand rise through the metal after it has entered the mold, and form slag pockets in the upper surface of these castings. Furthermore, phosphorized copper is extremely fluid and searching, and eats its way into the sand, thus producing rough castings. This may be remedied by the addition of silicon-copper. A piece as large as a walnut produces a marvelous change in a hundred pounds of phosphorized copper. The little dancing slag globules disappear, the brightness of the metal dies out, it assumes the appearance of bronze in the molten condition, and it casts exceedingly smooth. But alas! it is extremely drossy. The following alloys of copper with phosphorus were made and tested to determine their degree of hardness, to compare with a hard rolled copper commutator bar. They were tested by means of a chisel sharpened to a cutting edge, one inch in width, under a pressure of 9,000 pounds. With the rolled copper the point of the tool sank 1/16 inch under the above pressure. The first alloy consisted of copper 10 pounds, phosphorus 2 ounces. This was much harder than the rolled bar, the chisel making only a slight impression. The second alloy consisted

of copper 10 pounds, phosphorus 1 ounce, and was harder than the rolled bar. The third consisted of copper 10 pounds and phosphorus ½ ounce. This was found to be about the same degree of hardness as rolled copper, and was adopted as the alloy from which the burnt-out bars of the commutator were cast. The castings were dense and solid. Another alloy was made of copper 10 pounds and phosphorus ¼ ounce. This was soft, and its fracture showed minute pin holes. It evidently contained a little less than the minimum amount of phosphorus necessary to produce solid copper castings.—The Foundry.

ROBERT FULTON AND THE SIDEWHEEL STEAMBOAT.

BY J. H. MORRISON.

Who *invented* the steamboat? has been a question of much discussion at periods for many years in this country as well as in Great Britain and in France; but where the first steam vessel was built, or who was the designer, having the vertical sidewheels on either side of the vessel, has not been so generally a theme of discussion. That the side paddle-wheels of Fulton's "Clermont" was one of the factors, if not the main one, of his success, is undoubtedly true. John Fitch in 1787 built and operated the first steam vessel in this country, on the Delaware River, but the motive power was applied to a set of paddles on either side of the boat.

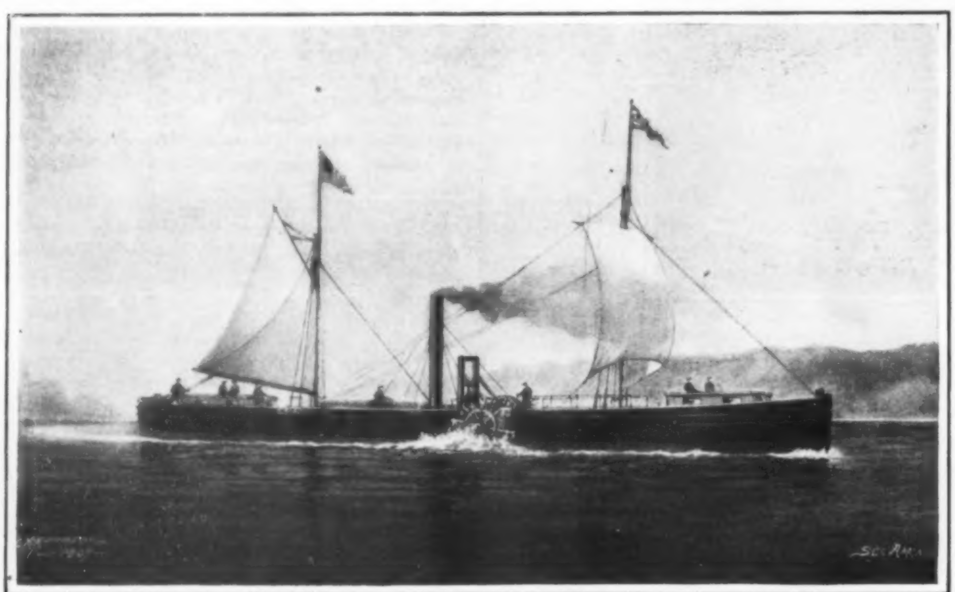
The trials and discouragements attending the early experiments lay in the fact that they were unable to find an agent that would propel a vessel at a velocity of more than about three miles an hour; and up to about 1784, when James Watt built his first rotative steam engine in England for stationary purposes, the steam engine was not in a form to adapt it for steam navigation with any prospect of success.

The propelling of vessels by paddle-wheels had been known to the Romans, for Appolo Vitruvius, the architect, in the fifteenth century, makes mention of two wheel boats, one having a pair, and the other five wheels on a side. These boats were to be operated by men, horses, or oxen. In the second volume of Harris's "Lexicon Technicum," printed in London in 1710, there is a description of an engine for rowing ships, having "paddles or wheels of six or eight on each side of the ship," to be operated by hand labor through the capstan, that was geared to the water-wheel shaft. The Chinese in the eighteenth century, according to the Jesuit missionaries at Peking at the time, had a war vessel fitted with two paddle-wheels on a side that was operated by men.

In this country the first mention of paddle-wheels is made by Benjamin Franklin in 1785 in his paper on "Maritime Observations," where he says: "Several mechanical projectors have at different times proposed to give motion to boats, and even to ships, by means of circular rowing, or paddles placed on the circumference of wheels to be turned constantly, on each side of the vessel. But this method, though frequently tried, has never been found so effectual as to encourage a continuance of the practice. I do not know that the reason has hitherto been given. Perhaps it may be this: that a great part of the force employed contributes little to the motion." He thought there was too much power lost in the movement of the immersed buckets through the water, to make the wheel of any practical use, which he described with a cut of a paddle-wheel. This was one year before Robert Fulton left the United States for Great Britain.

The earliest proposal for a steam vessel having vertical wheels at the sides, and to be operated by a steam engine, is in the description of a fire ship that was laid before the Lords of the Admiralty in England in October, 1796, by Edward Thomason. Patrick Miller, of Dalwinston, Scotland, obtained a patent in 1796 for a vessel to be "put in motion during calms and against light winds by means of wheels." "These wheels project beyond the sides of the vessel, and are wrought by means of capstans. . . . These wheels are built with eight arms, which consist entirely of plank." There is no record that any experiments were made under these proposals. Patrick Miller had made use of the vertical wheel in his experiments before this period, but it was with a single wheel placed between two hulls in a double-hull vessel.

The earliest use in this country of the paddle-wheel at the sides of a vessel was in an experiment made by Nathan Read in 1789, where he attached the paddle-wheels to an axis extending across the gunwales of the boat, that were turned by a crank. By this means he propelled himself by manual power across the river opposite Danvers, Mass., thus demonstrating in a small way that the side paddle-wheels had some merit as a practical means of navigation. A few years later, one of the most practical of the very few American engineers at that period, Nicholas J. Roosevelt, who had a foundry and machine shop at Belleville, near the present Newark, N. J., and who was interested with Robert R. Livingston and John Stevens at the time in their experiments with steam vessels, and was at a later date interested with Livingston and Fulton in their first steamboat enterprise on the western rivers, proposed to Chancellor R. R. Livingston in September, 1798, for one of their experiments, "that we throw two wheels of wood over the sides, fastened to the axis of the flys (flywheels) with eight arms or paddles; that part which enters the water of sheet iron, to shift according to the power they require either deeper in the water or otherwise." But no! Livingston, who had a system of propulsion that he considered to be superior to any other system, replied that "vertical wheels, they are out of the question." So they were never tried during the joint experiments of Livingston, Stevens, and Roosevelt.



FULTON'S STEAMER "CLERMONT."

A drawing prepared on the basis of old models and contemporaneous cuts and descriptions.

There were two other Americans who were engaged at an early period in experiments on steam navigation, whose claims for the adoption of the side wheels seem to merit attention. These experiments were the work of Samuel Morey, of Orford, N. H., who at a later date was a civil engineer and a contributor to the pages of our technical journals of that period. He commenced his experiments with steam vessels about 1790 on the Connecticut River, and three years later exhibited to Robert R. Livingston and others at New York a small steamboat fitted with a stern wheel that he had constructed. Being encouraged by the small improvements made from his many trials, and hopeful to obtain a better agent of propulsion, he continued his labors toward that end for a few years, and in June, 1797, went to Bordentown, N. J., on the Delaware River, where he constructed a steamboat. He was jointly interested in this enterprise with the Rev. Burgess Allison, who was at this time giving some attention to improvements in steam vessels. The latter had at one time a large academy for the instruction of boys in the sciences, and it was well equipped with apparatus for instructive experiments that were made by his own hands. Morey says of this experiment he "there devised the plan of propelling by means of two wheels, one on each side. The shaft ran across the boat with a crank in the middle worked from the beam of the engine with a shackle bar. . . . I found that my wheels answered the purpose very well, and better than any other mode that I had tried; and the boat was openly exhibited at Philadelphia." There does not seem to have been any record left of the dimensions of the vessel, nor where the engine and boiler were constructed. Dr. Allison says: "With a steam engine on board and wheels at the side, similar to those of Fulton's boats: and that she was exhibited in the presence of numbers of citizens with complete success. It was only for want of funds that we did not then bring it into public use." This was but a few years after the last of John Fitch's experiments with the steamboat on the Delaware River. Oliver Evans made use of a paddle-wheel in propelling his dredging machine at Philadelphia, in 1801, but the wheel was placed in the stern of the vessel.

Daniel Keller, of Huntington County, Pa., applied for a patent that was granted in May, 1795, "for an improved mode of propelling vessels by horses or oxen," the specifications and cut showing there were a pair of paddle-wheels near either end of the proposed vessel, that were to be driven by a bevel-geared motion from a platform located in the center of the length of the vessel. The cut giving an end view of a paddle-wheel, accompanying the patent, shows it to have eight arms. As this was the first patent issued in this country where the paddle-wheel is mentioned, and the fifth for an improvement in the propelling of boats, a part of the specifications relating to the propelling agent will be of interest at this time: "And fixed on the shafts crossing the boat at a right angle, in the ends of the shaft projecting from or over the boat, are arms supporting the oars, paddles, or floats, the whole of which to be of an optional length, thickness, and breadth. . . . In revolving, each oar, paddle, or float dips in the water in a rotary succession by means of the power applied to the arms of the main horizontal wheel, and from that to the specified wheels and shafts, constitutes the means of propelling boats." How much this patent had to do with the development of the paddle-wheel as an agent in the propelling of steam vessels in this country, after it became a matter of public record, is impossible to say at this late day.

It is thus seen from these proposals for side wheels, and the trials made with this type of propulsion, that they were some years prior to Robert Fulton's experiments with steam navigation in France. The Allison and Morey experiment on the Delaware River was evidently the first steam vessel to have two side paddle-wheels that there is any record of at this day, either in this country or in Europe. This was about six years after the close of John Fitch's experiments on the Delaware River, and about a year prior to Nicholas J. Roosevelt's suggesting the use of side wheels in his experiments where John Stevens and Robert R. Livingston were interested. Almost all the experiments made at this early period were with some agent to take hold on the water other than the paddle or bucket-wheel at the sides of the vessel, as the latter was considered out of the question, too absurd to be considered as a propelling agent, let alone to be adopted for experimental purposes.

It was but about two years after N. J. Roosevelt had suggested the use of side wheels in their experiments, that Robert R. Livingston was appointed by President Jefferson as minister to France, where he arrived in January, 1801. His relation to Robert Fulton, in his own language, is thus noted: "Robert R. Livingston, when minister in France, met Mr. Fulton, and they formed that friendship and connection with each other, to which a similarity of pursuits generally gives birth. He communicated to Mr. Fulton the importance of steamboats to their common country; informed him of what had been attempted in America, and of his resolution to resume the pursuit on his return, and advised him to turn his attention to the subject. It was agreed between them to embark in

the enterprise, and immediately to make such experiments as would enable them to determine how far, in spite of former failures, the object was attainable. The principal direction of these experiments was left to Mr. Fulton, who united in a very considerable degree practical to a theoretical knowledge of mechanics."

The union of the interests of Robert Fulton and Robert R. Livingston in the development of steam navigation at this time was the initial step that ultimately led to the construction of the first commercially successful steam vessel in the world. Livingston had been engaged in experiments with Stevens and Roosevelt for two or three years prior to his appointment as minister to France, although he had been interested in the subject for some time before taking any active part in the experiments. He was well informed, as were his associates at the time, of what was being done by others in this country toward improved methods of propelling a vessel by steam. Livingston says, after meeting Fulton, "informed him of what had been attempted in America." That the proposals made by Roosevelt to him "to throw two wheels of wood over the sides of the vessel," and the building of the steamboat by Morey and Allison with side wheels, that were both before Livingston went to France, were laid before Fulton for his consideration, with much other information on the same subject that had transpired in this country, is not for a moment to be doubted, as it was to their mutual interest.

Robert Fulton acquired all his mechanical knowledge and experience, prior to the construction of the "Clermont," while in Europe. He went to London in 1786 from the United States when twenty-one years of age, and spent two years in Devonshire, near the southwest coast of the British isle. His principal occupation would then appear for several years to have been portrait painting, and later mechanical drawing and sketching. He had resided during some of this early period in a part of the island where he acquired some knowledge of mechanics, and he no doubt put his skill for drawing to good use in the line of mechanical work. In 1796 he published a treatise on canal navigation, and during the latter part of the same year went to France, having spent about ten years in Great Britain. In December of the next year he made his first experiment with the torpedo, on the River Seine; and in July, 1801, made the first descent with his submarine boat in the harbor of Brest. He was now engaged for some years in experiments with the torpedo and the submarine boat, both in France and in England, and no doubt gained much mechanical knowledge from these trials that was of service to him in his experiments with the steamboat.

That Robert Fulton entertained the idea of the application of steam power for the propulsion of a vessel at an early date is found in a letter he wrote to Boulton & Watt on November 4, 1794, where he says: "I shall esteem it a favor to be informed of the expense of a steam engine with a rotative movement of the purchase of three or four horses, which is designed to be placed in a boat. You will be so good as to mention what size boat it would occupy, and I wish to have it in as little space as possible: and what you conceive will be the expense when finished complete in the boat. Whether you have one ready of the dimensions specified, or how soon one might be finished, with the weight of coals which it will consume in twelve hours, and quantity of purchase you allow to each horse. As I am desirous to apply some engines of the above dimensions as soon as possible, your immediate answer will oblige. ROBT. FULTON.

"Bridgewater Arms, Manchester."

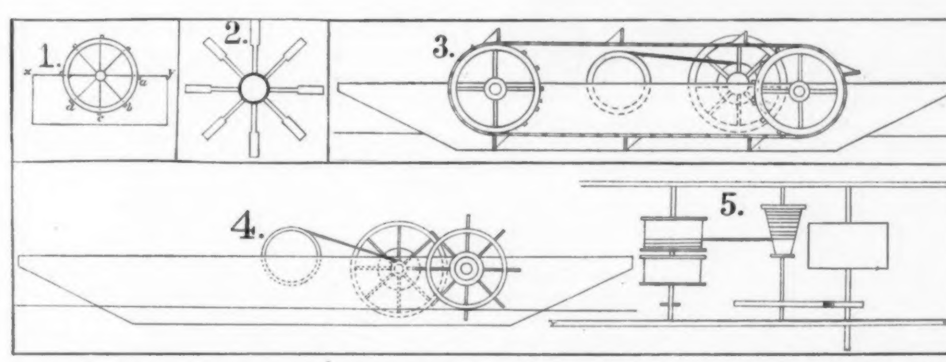
It was but a few months prior to the date of the above letter that the correspondence between Lord Stanhope and Robert Fulton occurred, where the former says on October 7, 1793, "in which you propose to communicate to me the principles of an invention, which you say you have discovered, respecting the moving of ships by the means of steam. It is a subject on which I have made important discoveries. I shall be glad to receive the communication which you intend, as I have made the principles of mechanics my particular study." Fulton also refers to his early consideration of navigation by steam vessels in the introduction in his treatise on canal navigation, where he says, "and having some communication with his Lordship on the practicability of navigating vessels by steam." It is to this correspondence with Lord Stanhope that so much claim has been made for Robert Fulton for his early adoption of the paddle-wheel, but there is no warrant for such a claim in any papers of Robert Fulton's that have thus far been brought to public notice. The production of the certified copy of Fulton's letter to Lord Stanhope of September 30, 1793, with the accompanying drawing, that was used in the New Jersey legal contest, and that was a cause of much strong feeling in the argument of the counsel on both sides at the time, would be of interest to show us what Robert Fulton did say on the subject. He wrote Lord Stanhope on April 11, 1811, saying in part, "You will recollect I wrote you in 1793 that I had a plan for upright oars or wheels to propel steam vessels"; and asking him to have a copy certified for his use. This was at the time he began his action against Aaron Ogden to prevent his running a steamboat in New York waters.

Cadwallader D. Colden in his "Life of Robert Fulton," 1817, makes the fatal admission that Benjamin Franklin had considered the use of waterwheels in propelling vessels in these words: "It may be well to remark here that the idea of propelling vessels by waterwheels, which at present are believed to be essential to the success of steamboats, had occurred to Dr. Franklin, but he rejected them as impracticable, and with his essay read before the American Philosophical Society . . . Dr. Franklin gives a drawing of a waterwheel accompanied by what he supposes to be a demonstration that they cannot be used to any advantage." As Dr. Franklin's consideration of the paddle-wheel was made in 1785, it thus disposes of any claim that could be made by the introduction of Robert Fulton's letter of 1793 of a claim of priority.

It is not at all probable that Robert Fulton was engaged in any experiments with steam vessels until after he met Robert R. Livingston in France. This was the period of the "Steam Mania," in Europe as well as in the United States, and Robert Fulton may have come under its influence and been attacked by the same fever of discovery as others at the time, and merely "thought of it." He had been largely occupied with his improvements of canal navigation, and later with his experiments on the torpedo, and his plunging boat or submarine vessel, in France. It was while he was thus engaged with the latter that he made his first experiments with steam navigation. These experiments were begun in 1802 with a small working model, on which he used among other means of propulsion the chaplet, that was a series of floats on an endless chain, on either side of the vessel: a system of paddles, ducks' feet, and later tried the paddle-wheel on the sides of the model. This latter system of propulsion offering much better prospects of good results, a boat was built of 66 feet length by 8 feet beam early in 1803, but owing to an accident when the vessel was nearly completed it became necessary to rebuild the hull. The trials in the following August with this boat were entirely satisfactory to all those interested, although the velocity was not as great as Fulton had anticipated. This boat was fitted with paddle-wheels on the sides. He had such confidence that this means of propulsion, with a type of engine that was better adapted to the purpose, would prove successful, that on August 6, 1803, he ordered from Boulton & Watt, of Birmingham, England, "a cylinder of a 24 H.P. double effect, the piston making a four feet stroke; also the piston and piston rod; the valves, and movements for opening and shutting them. The air pump piston and rod: the condenser with its communications to the cylinder and air pump." The work does not appear to have progressed very rapidly with this engine, for in the following July he gave the builders further directions regarding some of the minor parts of the machine. This was the engine, or the main parts of the engine, that was furnished by Boulton & Watt and fitted in the "Clermont."

Fulton's success in his early "experiments" came from his knowledge of mechanics, and to this may be added his keeping in touch with the experiments in steam navigation; and as his interest in the improvement of canal navigation, and later in the development of his submarine boat and his torpedo, must have brought him into contact with those who were at the time interested in the navigation of vessels by steam power, it cannot be doubted but that he had seen some of the experimental steam vessels prior to his taking up the experiments in France in 1802. Add the diversified experience he had obtained in the mechanical line prior to his meeting Robert R. Livingston, to the data laid before him of the many experiments made in this country for the moving of a steam vessel with side wheels, and it will be seen that Robert Fulton was well equipped to make the experiments in France. His residence in Great Britain brought him in contact with the most advanced thought on the subject of the steam engine and canal navigation, for it was in the British isle at this time that the most progress was being made in the useful arts and sciences. Added to this condition of his being in the circle where most of the works on scientific subjects, both ancient and modern, were to be obtained, and it is seen what a great advantage in the study of the many intricate problems on the subject he possessed over those who were operating for the attainment of the same object in this country.

That Robert Fulton was not *the inventor* of the steamboat has been very generally recognized for many years, though those interested with him in his enterprises at the time had laid claim to such title for him. His success dates from the time of the adoption of the vertical paddle-wheels at the sides of the vessel in his experiments, though they had been used by others in this country long before his trials in France. During his last legal contest that ended in 1815 over the steamboat "monopoly," where Aaron Ogden, of New Jersey, tried to prevent a steamboat that was run under the Livingston and Fulton privilege from running in the waters of the State of New Jersey, Robert Fulton wrote a letter to Aaron Ogden that shows how Fulton viewed the improvements he had made in his steamboats, upon which he had but a few years before obtained patents. "And I have sent certificates of two experienced English engineers who are now engaged in Talman & Ward's manufactory in the Bowery, who state that the links claimed by Mr. Dod as his invention have been on all of Boulton & Watt's engines for fourteen years. When I put these links in my patent, I did not patent them exclusively for all kinds of machinery, nor did I patent the steam engine, nor Charnock's tables. I made use of all these parts to express my ideas of a whole combination, new in mechanics, producing a new and desired effect, giving them their powers and proportions indispensable to their present success in constructing steamboats; and these principles, those powers and parts which I combined for steamboats, and which never before had been brought together in any steamboat, I patented for that purpose and no other." In his patent of February 11, 1809, he refers to the waterwheel: "I prefer a propelling wheel or wheels to take the purchase on the water. . . . Hitherto I have placed a propelling wheel on each side of the boat, with a wheel guard or frame outside of each of them for protection. A propelling wheel or wheels may be placed behind the boat, or in the center, between the connecting boats." He sums with the declaration, after giving a description of his discoveries, inventions, and improvements on steamboats: "Having mentioned the essential component parts of a steamboat, and its mechanism, its successful construction and velocity will depend, *First*, on an accurate knowledge of her total resistance while running 1, 2, 3, 4, 5, or 6 miles an hour in still water. *Second*, on a knowledge of the diameter of the cylinder, strength of the steam, etc. *Third*, on a knowledge of the square feet or inches which each propeller should have, and the velocity it should run to drive a given boat 1, 2, 3, 4, 5, or 6 miles an hour in still water. It is a knowledge of these proportions and velocities which is the most important part of my discovery on the improvement of steamboats." In his patent of February 9, 1811, Fulton says: "Give the following description of my inventions and discoveries for constructing boats or vessels which are to be navigated by the power of steam engines, believing myself to be the original inventor or discoverer of the following combinations." He then mentions the use of Boulton & Watt's steam engine, or any other steam engine of equal power, "my claim not extending to the steam engine"; then the mode to determine the dimensions of the hull of the vessel, he mentions of the propelling agency: "Having been the first to demonstrate the superior advantages of a water wheel or wheels, I claim as my exclusive right the use of two wheels one on each side of the boat to take the



MODELS USED BY ROBERT FULTON IN 1802, WHEN HE EXPERIMENTED WITH THE SYSTEM OF CHAPLETS, AND THE SIDE PADDLE-WHEELS. MADE FROM FULTON'S DRAWINGS.

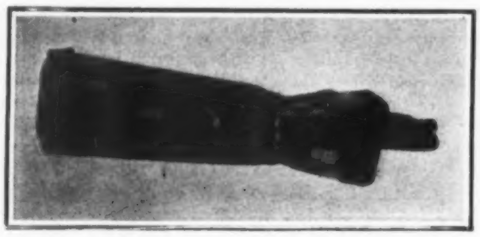
purchase on the water." Even with such a strong claim in his patent for the exclusive right to the use of two waterwheels, the infringements upon this one item were more than any other item in his patents on steamboats, and yet there is no record of a lawsuit brought for violation of his patent rights on that item. Fulton probably knew it would not hold water.

It will be noticed that Fulton claimed as his patent right *the combination* of the several parts in the construction of a steam vessel, and not of each individual part, as he was too well informed on the subject to make a claim for the separate parts of the combination. If he intended at any time after the "Clermont" was constructed to claim priority of invention of the steamboat in most of its parts, he was soon brought to realize during the suit against Aaron Ogden that improvements of the age were not known to a selected few.

This view of the case, that he was not the inventor of the sidewheel steamboat, can be further strengthened from a legal point, made at the time. In Robert Fulton's suit brought in 1812 for the possession of a steamboat, that was the example of the most flagrant piracy of his patented improvements of steamboats that could be thought of, Judge Joseph C. Yates, of New York Supreme Court, said in his opinion, after reciting the many statutes of the State giving Livingston and Fulton their privilege of propelling vessels by steam, says: "After the most minute examination of those statutes I cannot find that Mr. Livingston, originally, nor Mr. Fulton, subsequently, pretended to be the inventors of this steamboat. On the contrary, by a recital in the law of 1798 Livingston represents himself to be the possessor of a mode of applying the

MODERN SHEET-IRON HAND USED IN THE PERFORMANCE OF GOETHE'S DRAMA "GOETZ VON BERLICHINGEN."

steam engine to propel a boat on new and advantageous principles." Judge Smith Thompson also said: "The appellants do not in the case before us claim as *inventors*, but only as *possessors*, of a mode of applying the steam engine to propel boats on new and advantageous principles." Chief Justice James Kent at the same time said: "But the respondents show no patent, and the appellants have not obtained their grant as *inventors* of the steamboat, and therefore the privilege is totally unconnected with the patent power." Robert Fulton's counsel, the Hon. Thomas A. Emmet, in his argument in the New Jersey case in 1815, insisted that "Mr. Fulton, if he had not discovered in the first instance the original principles of the steam engine, had yet *combined* by the native force of genius simple powers of mechanism so as to



IRON LEFT HAND FOUND IN THE RHINE AT ALTRUPPIN.

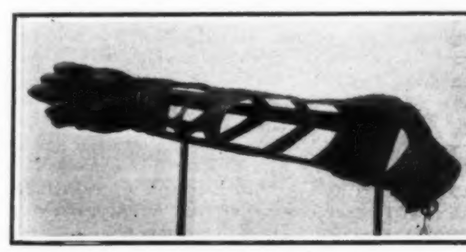
produce the important and beneficial effects which are observed in the present improved and useful state of steamboats."

Robert Fulton left a water-colored drawing of 1806, "showing the impropriety of making small paddles to a large boat, and seeking the impulse by giving great velocity to the paddles"; where he figures out by pulley and weights attached to a boat, and a paddle, "each presenting a flat front of four feet to the water," his calculations of the size of paddle wheel for the dimensions of the boat.

There was no part of the "Clermont" when completed for her trial trip that was original with Robert Fulton, though he obtained two patents at later dates in this country for improvements on the hull and engine of a steamboat, when patents could be obtained on application for them. His theoretical knowledge of mechanics, and its adaptation to practical purposes, was the one secret of his success in steam navigation. His thorough knowledge of the failures made by the many seeking for the coveted prize showed him to a great extent what features of a design to select that offered the greatest prospective value, and with good mechanical judgment brought together those parts of the motive power and propelling agency that made the "Clermont" a commercially successful steamboat. That the vessel at first was not entirely a success as a structure, is seen from the fact that after three months service she was subjected to many changes in hull, propelling agents, and motive power, through knowledge gained during the short period of her operation. That is no more than could be expected in such a radical departure in mechanics. Robert Fulton in less than three months after the vessel was in operation had in mind the building of another steamboat. He had noted that the "Clermont" was structurally weak, and required to make her fit for future service to have extra floor and top timbers, and knees with extra deck beams, and heavier deck plank, and to be sheathed over the outside planking; and if it was not better to build another vessel, such as experience would dictate, and use the material in the "Clermont" so far as possible in its construction. There has never been found, so far as all records show to this time, any plan of the vessel or model of the "Clermont." As the builder was one of the highest reputation as a shipbuilder at the time, he may have been given the dimensions of the vessel and estimated weights to be carried, and worked out such a plan of a vessel as he thought most adapted for the work to be done. But what became of the plans? Or was this during the "chalk" period?

While all credit must be given Robert Fulton for the first commercially successful steamboat in the world, still there is indisputable evidence, from the highest authorities on the subject, that the parts of that vessel that made it a success were the thoughts of other minds prior to his labors with steam navigation; for without the side paddle-wheels and the steam engine it undoubtedly would not have been a steamboat.

There has been little information handed down to us regarding the builder of the "Clermont," but such as we have shows that Charles Browne was a builder of vessels on Manhattan Island at the foot of Houston Street, East River, and having as high a professional reputation, and the most progressive, in his line of



A 15TH CENTURY IRON HAND IN THE BERLIN EDUCATIONAL COLLECTION.

business, of the constructors in the city, of which there were at the time comparatively few to what there were ten years later. In all probability he was the best qualified to work out the problem of a suitable type of vessel for the purpose. He had been established in business in 1807 about five years, and during that time had constructed six or eight sailing vessels for New York merchants.

IRON HANDS.

SOME CURIOUS OLD CONTRIVANCES.

BY F. M. FELDHAUS.

GOETZ VON BERLICHINGEN was a gallant German knight of the sixteenth century, who espoused the cause of the oppressed peasants because of his personal quarrels with their oppressors, and thereby won undying fame as a champion of liberty. Goethe made him the hero of a drama, which is based upon his autobiography. He was known as Goetz of the Iron Hand because he had lost his right hand in battle and wore an iron hand so skillfully contrived that he could guide his horse with it. Two iron right hands made for Goetz are still in existence and in the possession

GOETZ VON BERLICHINGEN OF THE IRON HAND. (BORN 1481, DIED 1562.)

of two branches of his family. One of them, the Rossach hand, is comparatively simple and crude. It can be opened and closed by moving a button at

THE EARLIER OR "ROSSACH" IRON HAND WORN BY GOETZ VON BERLICHINGEN.

16TH CENTURY IRON HAND IN THE COLLECTION OF COUNT WILCZEK.

the back, but the four fingers move as a unit. The little finger is now broken, but the mechanism is intact.

The Jagsthausen hand is more elaborate. Indeed, it is one of the most remarkable pieces of mechanism of its period. Each joint of the fingers can be moved independently of the others, and held in any desired position by a spring catch. When the large button at the wrist is pressed, all the fingers spring back to the extended position shown in the illustration. The thumb has a single joint which is governed by the

THE LATER OR JAGSTHAUSEN IRON HAND WORN BY GOETZ VON BERLICHINGEN.

small button near its base, and the entire hand can be rotated around the axis of the arm after it has been released by pressing a button at the back. The mechanism is still, in perfect order with the exception of the little finger, which has been paralyzed by the maladroitness of a modern investigator. The iron hand was fastened with leather thongs to the wearer's arm, the stump of which was inserted in the hollow upper part. It was used by bending the fingers, with the aid of the left hand, into positions suitable for holding reins, etc., and by releasing them on occasion by pressing the buttons.

A warrior thus handicapped would appear to be of doubtful value, but the case of Gen. Von Lane affords a parallel to that of Goetz von Berlichingen, except that in the modern instance it was the left hand that was replaced by an artificial member. In a letter to the writer the general says: "My left hand was carried away by a shell splinter in 1866. Pfister, of Berlin, made me an artificial hand, which could easily be closed so as to hold the reins, the only purpose for which I wanted it. I served as a staff officer through the war of 1870-1871. Since then I have taken part in hunts, and remained on the active list of the army until 1892." The general's artificial hand, which also can be turned about the wrist, has now been in use for forty years.

Berlichingen was not the first man to wear an iron hand. A hand and arm constructed in the fifteenth century, and now preserved in the government educational collection in Berlin, is herewith illustrated. The arm portion is of open-work construction, and has been mended in several places, so that it has evidently seen much service. The thumb is connected with the fingers in such a manner that it automatically approaches them when they are made to close, and the fingers straighten when a button at the back is pressed.

In deepening the channel of the Rhine in 1836, near the long bridge at Altruppin, the dredge brought up an iron left hand which is preserved in a local museum. It probably belonged to a warrior who was killed in some battle on the bridge. The upper part is made hollow to receive the stump of the arm, to which it was fastened by straps, and its weight is lessened by large perforations. As the illustration shows, the fingers are rigidly bent and are movable only in pairs about their attachments to the palm, while the thumb moves independently. The fingers are held in the desired positions by the two buttons shown at the wrist. Although this iron hand is badly rusted, the mechanism of the thumb is still in good condition. The curvature of the fingers indicates that the hand belonged to a horseman and that its principal function was to hold the reins. It probably dates from the beginning of the sixteenth century.

The Turkish pirate Horuk, known also as Barbarossa or Redbeard, a contemporary of Goetz von Berlichingen, also wore an iron right hand until his death in 1518.

An iron left hand made in France in the sixteenth century, and now in the possession of Count Wilczek, of Vienna, is herewith illustrated. It is similar to the Ruppin hand, but still simpler, as the thumb is immovable, and the movable pairs of fingers are merely kept closed by catches.

It is known that Duke Christian of Brunswick wore an iron left arm and hand that could be manipulated with the right hand and was made in Holland, but what became of it after Christian's death in 1626 is unknown. The Germanic Museum in Nuremberg possesses several crudely-constructed wooden hands dating from the seventeenth century.

In 1774 the Swiss mechanician Jaquet Droz, the constructor of the celebrated "Androids" or writing, drawing, and organ-playing automata, made a pair of artificial hands for a man who had lost both hands in a hunting accident. The artificial hands were so ingenious and efficient that they excited the admiration of the famous mechanician Vaucanson.

The first illustration shows an iron hand of modern construction which is used in the production of Goethe's drama, "Goetz von Berlichingen." It is made of sheet iron, but the same design might be carried out in heavier material, producing a practical and useful hand.—Translated for the SCIENTIFIC AMERICAN SUPPLEMENT from Redams Universum.

BIOGRAPHICAL X-RAY PICTURES OF RESPIRATION.

BY OUR BERLIN CORRESPONDENT.

THE biographic camera has during the last few years been used on a large scale for purposes of scientific investigation and instruction. By its means it has been possible to dissect and investigate the most difficult phenomena of motion, and by reproducing in rapid succession the several phases of a motion to reconstruct and demonstrate it before an audience. Motions either too rapid or too slow to be observed by the eye can be reproduced; thus botanists have succeeded in directly demonstrating the growth of plants.

Many endeavors have recently been made to utilize such demonstrations for medical instruction. Dr. A. Maclane Hamilton has demonstrated different gaits by means of a Lumière camera, while Dr. Doyen has succeeded in biographing various surgical methods. Dr. W. Greenough Chase, of Boston, has further recorded and reproduced by means of the biograph the convulsions of epileptics. The importance such records are bound to have for the instruction of medical students is evident, for even a practice of several years will not include all possible pathological cases.

At the recent X-ray Congress held at Berlin, Dr. Köhler, of Wiesbaden, aroused special interest by his biographical X-ray pictures of normal and pathological respiration. Though demonstrated by means of the biograph, these pictures had not been recorded with this apparatus. Though in principle 10 to 15 X-ray pictures of the thorax per second could very well be obtained, a special laboratory would be required for carrying along below the patient a film 16 inches wide and 12 to 16 inches long for each exposure at a rate of 15 exposures per second.

The pictures in question, a sample of which is given, were obtained by combining several X-ray diagrams produced with prolonged exposure. In the present case twenty to twenty-two different phases of each inspiration and expiration were fixed, and as each phase was projected two or three times successively, sixty pictures were obtained for a single respiration.

There are difficulties not only to the X-ray specialist, but also to the subject in obtaining these records. It is for instance extremely difficult to obtain a number of records of the same person with an absolute immovability of the diaphragm. Many records have to be discarded, while their number cannot be multiplied beyond a certain limit, lest the skin of the person be damaged. The greatest difficulty, however, is the impossibility of obtaining the same contrast and gradation on every plate.

Dr. Köhler showed two sets of pictures, all of which were obtained with the patient on his back with a focal distance of 30 inches, the exposure in all cases being 20 seconds. The X-rays were produced by a 45-centimeter (18 inches) induction coil in connection with a sliding contact interrupter and a Hermann-Köhler bulb at 32 volts and 4½ amperes.

One of these series of records is relative to a case of a nearly pure diaphragm respiration in a person whose thorax, owing to deformation of the ribs, was almost entirely rigid. An interesting phenomenon brought out by these records, and which apparently had never before been observed, is that in the case of a deep inspiration the two halves of the diaphragm will become flattened to straight lines sloping on both sides, while during expiration they are perfectly vaulted.

Radiographic reproductions of the lungs and diaphragm have frequently been made in medical institutes, and are not novel in themselves. It has even

THE LUNGS, SEEN FROM BEHIND.

been possible to photograph by means of X-rays several stages of respiration, such as for instance, extreme inspiration and expiration (but preferably the former). But this is the first time that photographs showing the *movements* of breathing have been taken.

The illustration shows a portion of a film with the thorax of a normal subject seen from behind. The practically horizontal wide strips are the ribs, while the big dark spot pointed on the top and broad underneath is the left hand lung. The triangular white portion in the left half of the thorax is the heart, while the brighter portion, limited by curves on the top, represents the two summits of the diaphragm (the right-hand summit being somewhat higher than the other) with the organs of the abdomen situated underneath.

It may be thought that biographic X-ray records could be obtained far more easily and with a far greater accuracy by directly photographing the image on a fluorescent screen by means of an ordinary biograph camera; as thick lead glass can be fitted to the screen while the camera can be mounted with lead walls, any diffuse X-ray radiation on the camera films could be readily eliminated. However, our present films and plates are not sensitive enough to the fluorescent light of barium-platinum cyanide screens, which for the time being makes the production of such biographical records quite impossible. Should a process for sensitizing the film in that respect be forthcoming a progress of great importance may be anticipated. Even in its present stage the biographical method is, however, likely to prove extremely valuable to medical science.

GREAT USE OF STONE.

THE stone produced in the United States may be classified broadly as granite, sandstone, limestone, and marble—names that are commercially convenient but by no means scientifically exact, especially as regards the rocks known as granites. Commercial granite includes gneiss, gabbro, diabase, andesite, syenite, and other rocks. Sandstone includes quartzites. On the other hand, certain fine-grained sandstones are known to the trade as "bluestone," and some Kentucky sandstones are marketed as "freestone." The term "traprock" is used commercially to denote certain basalts quarried in the northern Atlantic States and in California, and the production of this granite rock forms an industry so important that its value is shown separately in the United States Geological Survey's report on the production of stone in 1906, an advance chapter just published from "Mineral Resources of the United States, Calendar Year 1906."

The total value of the stone product of the country in 1906 was $66,378,794, an increase of $2,580,046 over that of 1905, and an increase of $42,413,565 over that of 1896. The value of the granite, traprock, marble, bluestone, and limestone increased, while the value of the sandstone decreased. The figures are:

Limestone	$27,320,243
Granite	18,569,705
Marble	7,582,938
Sandstone	7,147,439
Traprock	3,736,571
Bluestone	2,021,898

Almost all the producers, especially the small quarrymen, state that the cost of production was greater in 1906 because of the increase in the cost of supplies and in the rates of wages, especially for common laborers. The increased use of cement and concrete has also had an important effect on the stone industry.

Pennsylvania, producing chiefly limestone and sand-

stone, but also granite and marble, reported the greatest value of stone output for the entire United States, which was 13.27 per cent of the total; Vermont, producing granite, marble, and a small quantity of limestone, was second, with 11.34 per cent of the total; New York, producing sandstone, limestone, granite and marble, ranked third; Ohio, producing limestone and sandstone, was fourth; Massachusetts, producing granite, marble, sandstone, and limestone, was fifth; Indiana was sixth, followed by Illinois, Maine, California, and Missouri, each producing stone valued at over $2,000,000.

Massachusetts exceptionally ranked first among the granite-producing States in 1906, its great increase being due to large contracts for stone for the new Pennsylvania Railroad station in New York city. Pennsylvania led in sandstone and limestone. In marble, Vermont led, followed by Georgia and Tennessee.

Considered as to uses, the stone produced may be divided into building, monumental, flag, curb, paving, and crushed stone, the largest value being represented by building stone ($20,687,625), and the next largest ($17,467,486) by crushed stone, which is used principally for railroad ballast, road making, and for concrete. The production of crushed stone for use in making concrete showed a great increase, and the wider use of cement concrete will doubtless cause a still larger demand for stone in this form. Limestone is the stone most used for this purpose.

DEFORMATION AND VARIATION IN SEA LEVEL.*

BY H. W. PEARSON.

[The author contributes a paper to the London Geological Magazine in which he takes issue with the commonly accepted teaching that the surface of the earth is gradually rising in some places and sinking in others—as shown by the advance or retreat of the sea. He attributes this apparent variation to a real variation in the height of the sea, whose currents tend to bank the water against the coast in some places, and to draw it away in others. As ocean currents gradually change their course or velocity, so the apparent movement of the land is changed.]

Changes in the relative level of sea and land along the oceanic borders of the globe seem to have been in continual progress during the entire historic period. Too slow and gradual for direct observation, they can only be detected through comparison of ancient with modern maps, records, or statements. This comparison has now, in hundreds of cases, been made, and it is well established that stability of coastline is the exception, movement of elevation or depression the rule. In one region, it has been observed, the sea for long periods of time has been in continual retreat; at another location it has been long advancing over the land, while at some third point it seems to have remained fixed in position.

In the days of Linnæus and Celsius, when the uplift of the Baltic shores was first recognized, it was believed that this motion could be best explained by assuming an actual depression, or falling, in the surface of the sea, but since the time of Playfair this idea has been entirely abandoned, and all authorities now hold that these motions must be due to movement in the crust of the earth.

Playfair's law is, in effect, as follows: "By the principle of hydrostatic level, it is clearly impossible that the ocean should rise or fall *permanently* at one place without being similarly affected everywhere. It is certain, therefore, that the changes being in different directions in different places, must be due to movements of the solid crust." It seems that this conclusion, based upon an argument first advanced about a century since, yet remains unchallenged. The position assumed, at first glance, appears logical, plausible, and unassailable. Nevertheless, there are certain considerations arising from facts of recent development that should induce us to examine this problem anew. It will be seen that the entire weight of the above-mentioned argument is contained in the assumption: "It is absurd to assume a rise of the sea-level in one place and a fall in another at the same time" (Huxley, Physiography, p. 211); and if we find this position to be in error the long-adopted principle of Playfair must be held no longer tenable.

In opening this question anew, let us first give consideration to Mr. William Ferrel's law of deformation of sea-levels by ocean currents, contained in Science, vol. vii, p. 76. In this paper it is shown that oceanic currents impinging upon a shore-line have a tendency to elevate, those flowing away from a shore-line have a tendency to depress, the surface-level of the adjoining waters. A table is also given by which the amount of this deformation in any given latitude may be determined when the rate and direction of flow are known. By application of this table, and with the most conservative estimate that the Gulf Stream is flowing poleward at the rate of but four miles in twenty-four hours, Ferrel shows that the waters adjoining New York would be depressed about 5 feet below, and the waters adjoining Liverpool elevated 5 feet above, the normal sea-level, through the disturbing effect of the waters' flow. This total difference of 10 feet in elevation, however, he estimates will be cut down about one-half from the effects of under-currents impelled by the differing hydraulic heads above mentioned. His net result, therefore, is to find the waters around France and the British islands elevated some 2½ feet above, and those around New York depressed some 2½ feet below, the normal level of the sea. The values above reached, however, seem much smaller than the actual current velocities will warrant. Data from the papers and charts of the United States Hydrographic Office and the English Admiralty give results at least double or treble the value of four miles in twenty-four hours assumed by Ferrel. We must consequently conclude the waters adjacent to the British Isles to be elevated some 5 to 7 feet above the normal oceanic surface. To the north of England the current is compelled to a more northerly course. This change in direction, combined with the effect from the more rapid shortening of the cosines of these latitudes, seems to make necessary on the coast of Norway a still greater rise in surface elevation that has already been determined for the coasts of England. This writer, with data somewhat uncertain both as to direction and velocity, has reached results off the north coast of Norway calling for an elevation of over 20 feet in the surface-waters on these shores. This amount, if reduced one-half by escaping currents as estimated by Ferrel, would still leave deformation of over 10 feet.

Applying in similar manner Ferrel's law to other ocean currents, we find deformation in sea-level to obtain on every coastline on the globe. Nowhere do we find a level surface. For instance, that current which in more northern regions becomes the Gulf Stream is first recognized somewhere south and west of the Cape of Good Hope. At this latitude the surface of the earth is rotating to the east at a rate of about 790 miles per hour. At the equator the rate of rotation is 1,040 miles per hour. These waters, therefore, before passing the equator, must undergo an acceleration of some 250 miles per hour. Some of this acceleration will be obtained from impulse of the surrounding waters, some possibly from contact with the bottom, but the final acceleration must certainly be reached by the crowding of these waters against the entire eastern shore-line of South America, where deformation of level in the surface-waters must necessarily occur. It follows, as a consequence, that a deformed and elevated water-surface must exist along the entire coastline of Brazil. Furthermore, we might infer that the south-flowing Brazilian current, like its prototype on the east coast of England, is an escaping, or secondary, current, impelled by the hydrostatic head in existence on those shores, as already suggested by Ferrel.

In the Gulf of Mexico an elevated surface is necessarily established by the united effect of the Equatorial and Gulf Currents. A gradually declining surface from Florida to Nova Scotia and Greenland should also be expected as we pass to the north, due to the retreat of the Gulf Stream from these shores. Some local elevation in the vicinity of the continental projections of Nova Scotia should also appear, from the uplifting effect of the south-flowing Labrador current. On the European coasts a progressive rising gradient should be found from Africa northward to the shores of Nova Zembla. Ferrel's law teaches us, therefore, that as long as ocean currents flow upon a rotating earth it is impossible to expect that confluent seas in differing latitudes, on any one coastline, should have the same absolute surface elevation. It will now be observed that the magnitude of these deformations in oceanic surface as demanded by our law are such as to make their discovery almost a necessity. We are therefore justified in searching the records of leveling operations with the view of learning to what extent Ferrel's deductions may be confirmed by actual fact. Below we quote a few results arrived at from lines of precise levels, extended at different dates through Europe, the United States, and Canada. This list might be considerably enlarged, but the result would be invariably the same. All lines of level confirm Ferrel.

Precise levels in England indicate that "the sea-level of the northern part of the island generally is higher than that of the southern part." (U. S. Coast Survey Rep., 1874, p. 256.)

The Encyc. Brit., vol. xxii, p. 708, says: "Lines of level carried across the continent of Europe make the mean sea-level of the Mediterranean, at Marseilles and Trieste, from 2 to 5 feet below that of the North Sea and the Atlantic, at Amsterdam and Brest, a result which is not easy to explain on mechanical principles." Other differences are shown between the Mediterranean and North Sea as follows: Through Prussian levels, 0.757 meter, *via* Alsace 0.809 meter, through Switzerland 0.832 meter, between Trieste and Amsterdam (*via* Silesia and Bavaria) 0.59 meter. (Science, vol. iii, p. 54.) In Science, vol. vii, p. 75, we are told by Ferrel that the mean level of the harbor of Brest is 1.02 meters higher than the surface-level of Marseilles.

In the United States we find the same condition. Some twelve or fifteen lines of levels from various points on the Atlantic coast result invariably in determining the Gulf of Mexico to be elevated above the waters of the Greater Ocean.

Hilgard in 1884, from three sets of levelings, showed the Gulf at New Orleans as one meter higher than the Atlantic at Sandy Hook. (Science, vol. iii, p. 504.)

Mr. John F. Hayford, in Appendix No. 8 (U. S. Coast and Geol. Survey Reps., 1899, pp. 397-431), has shown that the average of six lines of precise levels run across Florida, from St. Augustine to Cedar Keys (1892, 1893, and 1894), gave as result the Gulf to be 0.2585 meter above the Atlantic. He also shows that a line from Old Point Comfort on the Chesapeake to Biloxi, Miss., found the excess in surface elevation of the Gulf to be 1.028 meter, and a series of levels from Sandy Hook to Biloxi—evidently not the same lines as those mentioned by Hilgard and Schott—resulted in a difference of 0.385 meter.

In 1883 to 1886 the Canadian Department of Public Works caused a line of levels to be run from Quebec to Rouse's Point, N. Y., where a bench-mark of known altitude above mean sea-level at Sandy Hook had been established by the U. S. Engineers. The result of this line was apparently to establish the fact that the sea-level at Quebec was some 5½ feet below that of New York (5.52 feet). This determination was unexpected to this writer, as from the application of Ferrel's formula it would appear that the elevating effect of the southward-flowing Labrador current, in immediate contact with the shore-line, would be much in excess of the depressing effect of the distant Gulf Stream. It seemed, therefore, impossible to explain mathematically this surprising lack of elevation in the St. Lawrence.

Such explanation, however, no longer seems necessary. In the Trans. of the Can. Society of Civil Engineers for 1903, it has been shown by W. B. Dawson that the Admiralty datum at Quebec is 8.58 feet below mean sea-level, and that by reason of this the mean sea-level at Quebec had been assumed as about 8 feet too low. This would imply that the observed sea-level in Quebec was 3½ feet higher than the sea-level at New York. Ferrel's deductions are thus again confirmed. It would seem that the illustrations above given are ample to establish the fact that Ferrel's law is supported by actual differences in level of which we have knowledge.

Heretofore, these differing elevations have been held as doubtful, absurd, and unexplainable. They have been regarded as in opposition to mechanical principle. The officers of our own Coast Survey have rejected them utterly. They have held the Gulf and Atlantic to be at the same elevation, and have assumed the apparent elevation of the Gulf as due to some mysterious and systematic series of errors in leveling, by which, under some process still more mysterious, these distortions of fact have been made to appear always in one direction. Giving expression to their beliefs, they have also arbitrarily "adjusted" the elevations of some 4,000 bench-marks of the precise level lines of the United States, in an effort to eliminate these unexplainable differences. (See Report Coast and Geod. Survey, 1899, App. 8.)

The logic, the unquestioned value, the simplicity of Ferrel's law, however, now bring fact and theory once again into harmony. In the ocean currents, crowding against, or flowing from, the oceanic coastlines, we find perfect explanation of all known cases of discrepancy in altitude. We are now in position to advance one step farther in our examination as to the truth of Playfair's law, and may reason somewhat as follows: It will be admitted, I think, that the argument above presented has considerable weight, that there is mathematical support to Ferrel's con-

* Abstracted from the Geological Magazine.

tention, and that when we assume the surface of the sea to be held at abnormal levels of elevation or depression, determined by the rate and direction of flow, there is logic and merit in our position. Now, then, if these waters are so held at elevations of 3, 5, or 10 feet above or below the normal, depending on the direction and velocity, it is an incontestable deduction that if the slightest change in direction or velocity of these currents takes place, these waters should immediately alter their surface-level in corresponding degree, a rising sea-level at one location being necessarily accompanied by a falling sea-level at some not distant point.

We will now examine as to the probability or possibility of the occurrence of such suggested diversion and variation in currents. This question is almost a new one, but no difficulty should be encountered in entertaining the conception that such changes may have taken place in the past, notwithstanding the dearth of observation in this regard.

Pillsbury's study of the Gulf Stream has shown daily, monthly, and annual variations in flow, but these changes, owing to their short period, probably have little effect on the sea-level at distant points. His observations were not extended over a sufficient number of years to determine cycles of long period, but certain observations in this direction have been made by others, which are of such importance and have such direct bearing on the problem as to entitle them to mention. In "Prehistoric Europe" Mr. James Geikie, from consideration of the variation in lifeforms between Cape Cod and the Bay of Fundy, inferred that the Gulf Stream formerly carried into the north a "much greater body of heated water than now reaches such high latitude." Dr. James Croll, from study of the fossils in the Carse clays of Scotland, held that when these clays were deposited the mean winter temperature must have been 10 deg. or 15 deg. lower than at present, and that the Gulf Stream was then "considerably reduced." ("Climate and Cosmology," p. 115.) The recency of this change is affirmed by the fact that these clays contain many buried canoes and other relics of early man. In Popular Sci. Monthly, vol. xx, p. 668, Mr. James Geikie is again quoted. He therein shows that the climate of northwestern Europe has been, and may again be, modified by changes in the flow of the Gulf Stream. In the Smithsonian Report for 1869 M. Babinet discusses the deterioration in climate of Greenland and the Arctic regions generally during the last few centuries. His conclusion is that the only explanation of many observed facts connected with the movements of ice masses and variation of climate in those regions is found in a "diminution" of the Gulf Stream, and he "boldly affirms" that the current passing around North Cape is now decreasing and carrying less heat than formerly. Other changes in direction or velocity have been either actually observed or inferred from indirect evidence.

Humboldt informs us that a current near the Bahamas flowed to the southeast in 1787. It now flows to the northwest at a velocity of 26 miles a day. Repeated statements have been made that at different times in the past the cod or herring industry, off the coasts of Ireland, Scotland, Denmark, and France, has been ruined or injured by the migrations made necessary by the diversions of ocean currents. Dr. Bessel has shown that the currents of Davis Straits formerly ran in an opposite direction. Reclus has shown also that during the Tertiary period the Gulf Stream along the coast of Cuba had direction differing from that of the present. It will be admitted that the citations above given in no case seem conclusive. They are mostly deductions made by those who have otherwise been unable to explain observed phenomena. Nevertheless, the established positions of many of those who have drawn these conclusions and the profound respect we entertain for their judgment should warrant us in accepting their decisions as most certainly probable. We may adopt, therefore, as most reasonable, even if not yet firmly established, the following proposition: Variation and diversion of ocean currents have certainly occurred in the past. It is probable that these changes may be going on to-day, and it is certain we must expect them in the future.

Now, then, it seems a mathematical certainty that if either variation or diversion in flow of ocean currents takes place the surface-levels on all coastlines must change in due proportion, and that these changes must necessarily be in opposite directions in not distant locations. During the full lifetime of the science of geology we have been utilizing the apparent motions in the earth's crust herein considered as types, as living illustrations, of that uplifting of continents, that slow growth in mountain chains, required by our modern doctrines.

But if Playfair's law has during this time occupied a position to which it has no title we must reconsider our premises.

THE DISTRIBUTION OF THE STARS.

THE WONDERS OF THE SIDEREAL SYSTEM.

BY HECTOR MACPHERSON, JR.

Even to the unaided eye, it is obvious that the stars are not evenly distributed over the heavens. The eye is at once attracted by such brilliant regions as Orion and Cygnus; while in Virgo and Capricornus there is plainly a dearth of stars. As Mr. Gore points out, of stars brighter than the second magnitude, of which there are thirty-two, twelve, or more than one-third, are on the Galaxy or on faint nebulous light connected with it, and yet the area covered by the Galaxy does not exceed one-seventh of the whole heavens. This shows plainly that the stars are more numerous in the direction of the Galaxy than in other parts of the heavens. With a telescope the increase of stars in the galactic direction of the heavens is more apparent. In 1904 and 1905 the writer surveyed several hundred stars in all parts of the heavens with a 2-inch refractor, counting the fainter stars in the vicinity of brighter stars. Even with a small instrument the preponderance of stars in the Galaxy is at once obvious. In a telescopic field in Cygnus and Cassiopeia, for instance, the average number of stars ranges from forty to sixty; while in a similar field in Capricornus and Virgo the average number is five or six. With larger instruments, of course, the increase is more obvious, as for instance with Herschel's reflector, which enabled that great astronomer to ascertain for the first time the crowding of the stars toward the Galaxy.

When we come to examine great masses of stars the increase of stars toward the galactic belt is seen to be one of the laws of the stellar universe. In 1870 Proctor plotted on a single chart all the stars, to the number of 324,198, contained in Argelander's great "Durchmusterung" charts. The result was to show that, in his own words, "in the very regions where the Herschelian gages showed the minutest telescopic stars to be most crowded, my chart of 324,198 stars shows the stars of the higher orders down to the eleventh magnitude to be so crowded that by their mere aggregation within the mass, they show the Milky Way with all its streams and clusterings."

This was confirmed by Houzeau of Brussels, and by the two Milan astronomers, Schiaparelli and Celoria. Schiaparelli confined himself to the lucid stars, those visible to the unaided eye, and the result of his work is to show that supposing the Milky Way were itself obliterated we could still trace its course by the number of stars which aggregate toward the plane of the Galaxy. Mr. Gore finds that stars of each individual magnitude taken separately tend to aggregate on the Galaxy. From an enumeration of the stars down to the sixth magnitude, he shows that "the percentage of stars on the Milky Way is 22.1, or about one and a half times that due to its area." He also says: "The apparent connection of some of the naked-eye stars with the brighter portions of the Milky Way is in some cases remarkable. The stars Alpha, Beta, Gamma, Eta, and Kappa Cassiopeiæ mark a very luminous spot of milky light. The stars Iota, Kappa, and Lambda Andromedæ mark another. Delta, Epsilon, and Zeta Cephei lie near the edge of a 'coal sack,' or dark space in the midst of a luminous region. The stars Epsilon, Xi, Zeta, and Omicron Persei mark an off-shoot from the Galaxy in the direction of the Pleiades." Another interesting example, not pointed out by Mr. Gore, is the region of Deneb or Alpha Cygni as observed with the binocular. In August, 1904, the writer noted that "the boundary between the galactic light and the darkness of the small rift near Alpha Cygni is marked by a line of stars which appears distinctly connected with the nebulous light of the Galaxy." This field is one of the most striking examples of the connection of the lucid stars and the galactic star-clouds.

The Dutch astronomer Easton has ascertained that the fainter stars in Argelander's catalogue, about 9.5 magnitude, "present in the manner in which they are distributed, a remarkable correspondence with the luminous and obscure spots in the Milky Way." Celoria finds that among the fainter stars there is a marked increase of stars toward the Galaxy. Seeliger in his researches divides the sky into nine zones, each twenty degrees in breadth, by small circles parallel to the Galaxy. As the writer has said in "Astronomers of To-day": "In Prof. Seeliger's first region is included 4,277 stars, in the second, third, and fourth, respectively, 10,185, 19,488, and 24,492 stars. The maximum is reached in the fifth region, which contains 33,267 stars, and it is to be noted that this is the galactic zone. The sixth region contains 23,580 stars, and the seventh, eighth, and ninth, respectively, 11,790, 6,375, and 1,644 stars. The number of stars gradually increases from each of the galactic poles to the Milky Way itself."

The Galaxy seems, therefore, to be the ground plan of the stellar universe, "the ecliptic of the stars," as the younger Herschel called it; and the aggregation of stars toward the galactic plane is admitted on all hands. The problem of how to interpret this fact has exercised the minds of astronomers since the time of the elder Herschel. There are three possible explanations of this aggregation, which are: (1) Uniform distribution of stars, but further extension in the galactic line of sight; (2) Greater condensation of stars in the Galaxy than elsewhere; and (3) Greater condensation and at the same time greater extension. The first of these explanations was at first accepted by the elder Herschel in 1785 in his famous disk theory of the universe. He assumed the stars to be distributed on the whole in a uniform manner throughout space, but the stellar universe to have a greater extension in the galactic line of sight. Herschel was thus able to compute the shape and extent of the universe, which he regarded as finite. He sketched the disk as cloven at one of its extremities to represent the famous gap in the Galaxy. He soon found, however, that the disk theory failed to explain the observed facts, and that the stars were by no means uniformly distributed; so he abandoned the theory definitely in 1811, and he never put forward another hypothesis to explain the crowding of the stars on the Galaxy. The elder Struve attempted a modification of the disk theory, which never became popular among astronomers and was abandoned years ago. He regarded the stellar universe as a disk of certain thickness, but of infinite diameter. His idea was that the light from the farther stars in the direction of the Galaxy suffered extinction in the ether, and thus he explained why, granting the infinity of the Galaxy, the entire heavens did not shine with the brightness of the sun. Sir John Herschel and Grant, of Glasgow, gave the death blow to Struve's theory, which was never accepted. Proctor, who was the next great student of star distribution after Struve, threw over the fundamental idea of the disk theory—equal scattering. He pointed out that "within one and the same region co-exist stars of many orders of magnitude, the greatest being thousands of times larger than the least." This is a conclusion quite different from the disk theory, where the stars were supposed to be on the whole distributed uniformly and to be of a uniform size.

Celoria and Seeliger both consider the Galaxy to be a zone of stellar condensation, where the stars are smaller and more closely crowded together than in other parts of the heavens. Newcomb, however, also thinks that "the universe extends farther around the girdle of the Milky Way than toward the poles of that girdle," and that "outside the galactic region the stars in general show no tendency to collect into systems or clusters, but are mostly distributed through space with some approach to uniformity." In regard to the distances of the galactic stars, Proctor thought the stars which make up the milky light to be smaller than the brighter stars and to be at a smaller distance than their faintness would lead one to suppose. Easton points out that "in general the faint stars which form the Milky Way are thickly or sparsely scattered in respectively the same region as Argelander's last class; it follows, therefore, with a great degree of probability that there is a real connection between the distribution of ninth and tenth magnitude stars and that of the very faint stars of the Milky Way. Consequently the very faintest stars are at a distance which does not greatly exceed that of 9-10 magnitude stars. If stars of 11-15 magnitude were at their theoretical distance, there would be no reason why they should have the same apparent distribution as 9-10 magnitude stars, separated from them by enormous distances."

The galactic zone, though part and parcel of the stellar universe, seems to have several well-marked characteristics of its own. Kapteyn, Gill, and Pickering independently discovered the predominance of first-type stars in the Galaxy; while Kapteyn showed that the near vicinity of the sun consists almost exclusively of stars of the second type. Another peculiarity of the galactic region is that outbursts of temporary stars are commonly confined within its bounds. The photographs of Wolf, too, have revealed in Cygnus, Aquila, and other galactic constellations, enormous masses of nebulæ intermixed with the stars. This seems to point to the stars of the Milky Way

being relatively younger than those in other regions of the heavens, and to the zone being in a more chaotic condition than the vicinity of our sun.

Sir John Herschel believed the Galaxy to be a ring formation, and Proctor put forward the view that it was of a spiral form, the gaps and "coal sacks" being due to loops in the stream. Both Gould and Celoria thought that the Milky Way is really composed of two galactic rings, but neither of these ideas has been accepted. There seems to be no doubt that the Galaxy is a ring formation and a distinctive part of the universe, but as Seeliger points out, "it is no mere local phenomenon, but is closely connected with the entire constitution of our stellar system." The number of stars in Seeliger's enumeration increases from each of the galactic poles to the Galaxy itself. This shows that the Galaxy is not merely a ring of stars surrounding a star sphere, for if such were the case, the number of stars would increase not speedily but suddenly, near the boundary of the ring.

Sir John Herschel considered that our sun is not placed centrally in the plane of the Milky Way; and the idea is confirmed by Celoria, whose observations indicate that we are nearer to Aquila than to Monoceros. The idea that the sun and nearer stars form a separate cluster has been abandoned by Kapteyn, its author, whose recent researches on star streams have led some astronomers to the conclusion that the universe is double; but it is obviously too early to formulate any definite theory on this point.

With regard to the distribution of stars in the universe, the Galaxy seems to be a real region of condensation; and at the same time the universe probably extends further in the direction of the Galaxy than in the direction of the galactic poles. In the latter direction, in fact, the limits of the universe have been reached by Celoria's telescope before the eleventh magnitude, and this fact supports Newcomb's view that the universe is farther extended in the galactic direction; but it is quite evident that even in the Galaxy itself the stars thin out at the lower magnitude, and the rifts and coal sacks indicate that there are no farther stars in their respective directions. If the views of Newcomb and Seeliger are correct, the universe would seem to be of a roughly spherical shape, flattened at the poles, with an equatorial bulge; and the equatorial region would seem to be densely crowded and at an early stage of evolution. But as Mr. Gore has truly remarked: "The Copernicus of the sidereal system has not yet arrived and it may be many years or even centuries before this great problem is satisfactorily solved."—Popular Astronomy.

THE DIVINING ROD.

In experiments with a divining rod as used for discovering underground supplies of water, one of the geologists of the United States Geological Survey found that at points it turned downward independently of his will, but more complete tests showed that the down-turning resulted from slight and—until watched for—unconscious changes in the inclination of his body, the effects of which were communicated through the arms and wrists to the rod. No movement of the rod from causes outside the body could be detected, and it soon became obvious that the view held by other men of science is correct—that the operation of the "divining rod" is generally due to unconscious movements of the body or of the muscles of the hand. The experiments made show that these movements happen most frequently at places where the operator's experience has led him to believe that water may be found. The uselessness of the divining rod is indicated by the facts that the rod may be worked at will by the operator, that he fails to detect strong currents of water running in tunnels and other channels that afford no surface indications of water, and that his locations in limestone regions where water flows in well-defined channels are rarely more successful than those dependent on mere guesses. In fact, its operators are successful only in regions in which ground water occurs in a definite sheet in porous material, or in more or less clayey deposits, such as the pebbly clay or till, in which, although a few failures occur, wells would get water anywhere.

Ground water occurs under certain definite conditions, and as in humid regions a stream may be predicted wherever a valley is known, so one familiar with rocks and ground-water conditions may predict places where ground water can be found. No appliance, either electrical or mechanical, has yet been successfully used for detecting water in places where plain common sense or mere guessing would not have shown its presence just as well. The only advantage of employing a "water-witch," as the operator of the divining rod is sometimes called, is that skilled services are obtained, most men so employed being keener and better observers of the occurrence and movements of ground water than the average person.

The railways of the world had a total length of 563,772 miles on January 1, 1906, according to German statisticians. Of this amount 215,713 miles were in the United States and 192,248 miles in Europe. New construction during 1905 added 12,524 miles to the total, of which 2,485 miles were in Europe. Germany showed the largest increase, building six times more road than Great Britain. Considerable progress was also made in constructing railways in Africa, particularly in the German possessions.

SCIENCE NOTES.

Madame Curie finds that the active deposit resulting from the decomposition of a constant amount of radium emanation is precipitated upon plates in amounts depending upon their position. The activity of plates facing upward is always greater than for other positions. The effect is the same as though the deposit consisted of heavy particles falling through the gas. When no gas is present, however, the amount does not depend upon the aspect of the plate; and to the present writer this fact is in opposition to the view that the action is a direct gravitating one, for falling would then be still more complete in the absence of the gas. The action is apparently a secondary one, in which gravitation is involved. This conclusion seems to be borne out by the further fact that the presence of moisture is also necessary.—Knowledge and Scientific News.

When ultra-violet light is incident upon negatively charged metals they gradually discharge. Two views have been held regarding the mechanism of this discharge. According to the first view it is the quasi-free electrons—which take part in electric conduction—which acquire sufficient additional kinetic energy from the light to enable them to overcome the attraction of the metal. According to the second view the electrons concerned are constituents of complex atomic systems, which become unstable under the influence of the light, and they become projected from these systems with velocities not greatly different from those which they possessed inside the atom. If the first view were correct, temperature might be expected to have considerable influence upon the rate of discharge; for the quasi-free electrons possess a velocity, given by the ordinary gas theory, which is proportional to the square root of the absolute temperature; therefore, at high temperatures less increment of energy would be required in order that the attraction of the metal might be overcome, especially as the attraction, if also a function of the temperature, probably decreases as the temperature rises. According to the second hypothesis, the velocity possessed depends upon the internal constitution of the atomic system, and may be expected to be independent of temperature. It becomes important, therefore, to prove whether or not temperature has any influence. Evidence so far has been very conflicting; but it has to be borne in mind that experimentalists have nearly always made their observations in air or other gas. All such experiments may at once be ruled out, for the presence of a gas introduces so much complication that the true photo-electric effect is masked. Elster and Geitel alone, till recently, record measurements made in a good vacuum, the metal upon which they worked being potassium, and obtain an increase with increase in temperature. The question has now been fully investigated by Prof. Millikan and Mr. Winchester, and their latest account is given in the Philosophical Magazine for July, 1907. Experimenting in the best possible vacuum on the metals copper, gold, nickel, brass, silver, iron, aluminium, magnesium, antimony, zinc, and lead, they find no effect whatever from a rise of temperature from 25 deg. C. to 125 deg. C., upon the rate of discharge of negative electricity under the influence of light. In the same paper they show that the positive potentials acquired by the same metals when under the prolonged influence of the light are also independent of temperature, a result which led to Lenard's conclusion that the only forces resisting the expulsion of the negative particles are electrical in their nature. They further confirm Lenard's conclusion that the positive potential acquired is independent of the intensity of the incident light. They have come to the following conclusions, which differ from those which have frequently been arrived at when the experiments were conducted in air: The order in which metals in a vacuum exhibit photo-electric sensitiveness bears no relation whatever to the volta contact series. The order obtained is that given in the above list, with copper at the top, and lead at the bottom. The order in which the metals arrange themselves with respect to the positive potentials assumed in a vacuum under the influence of ultra-violet light bears no relation to the volta contact series. Clean, unpolished metals exhibit in a vacuum under the influence of a given source perfectly definite and constant discharge rates. If fatigue effects occur at all, the recovery from them is complete in the course of a few minutes. Of course, these statements are not a denial of the reality of the similarity with the volta series, when the experiments are conducted on a gas. In such cases the complication due to the gas is of the same kind as that which gave rise to the great controversy on the seat of the electromotive force of a voltaic cell.

ENGINEERING NOTES.

The Bessemer & Lake Erie Railroad is planning to use steel ties next year. About 70,000 ties will be necessary for renewals and repairs in place of wooden ties now in use, the lines on which they will be used aggregating 90 miles. On the roads controlled by the United States Steel Corporation about $500,000 worth are in use, sufficient for about 160 miles of track.

The production of denatured alcohol for the first six months of 1907, under the new law, was 1,774,272 gallons. The supplemental free alcohol law will, it is estimated, lead to the production of 4,000,000 gallons for the calendar year. The operation of the law reduced the cost of wood alcohol from 60 to 30 cents a gallon, which has greatly benefited consumers.

British municipalities are very jealous of any possibilities for "graft" among their employees. Officers of the London County Council are not allowed to take out patents without receiving special sanction. This sanction has just been given to one of the engineers, who has devised an improved point for use in connection with the side-slot system of conduit tramway electrical traction. The council imposes the condition that it shall have the right of using the invention if it so desires.

Experiments have been made in England with pieces of the goldbeater's skin of which the envelope of a military balloon was made, in order to discover what effect the shots of an enemy would have upon the balloon. The pieces of skin were shot at from every possible angle and range, and no greater damage was inflicted than that of making holes the size of the bullets. To increase the safety of the balloon, the gas bag was divided into independent compartments, so that, should one or two compartments become damaged, the flight of the balloon would not necessarily be stopped.

Road improvements in Athens, N. Y., have not found favor with the conservative majority of its people, and the progressive element considered strong measures necessary. One morning the center of the town's leading thoroughfare was found planted with several rows of cabbages. The town council was stirred to action, and consulted a local inventor as to what should be done. He decided that the street had a gravel bottom, and by pouring tar on it a good pavement would result. He was so confident in the success of the method that he offered to furnish the labor if the council would supply the tar. Two blocks were covered in this way on the first day, but the conservatism of the town revolted, and the next morning the street was found coated with feathers.—Engineering Record.

In the big yards of the Pennsylvania Railroad at Pittsburg and Altoona, fire pumps and hose are attached to all switch engines and their crews are systematically trained as fire brigades. The yards are divided into districts, numbered as are fire alarm boxes in cities. When a fire is discovered, the nearest switch tower is notified and alarm whistles are blown throughout the yard limits. By a code of signals, engineers of locomotives within the yard can tell from the whistles just where the fire is. Each engine at once uncouples from its draft of cars as soon as the latter can be placed where they will not obstruct main tracks. Yard masters and train directors give necessary orders to provide a clear track to the scene of the fire, signals are set indicating the routes by which to reach the fire, and by the time they arrive their crews have pumps unlimbered ready to work and hose ready to unreel. In the fire organization the assistant yard master acts as chief, and gives general directions both in fire fighting and in drills. The conductor of each train crew acts as foreman of that crew; the flagman looks after unreeling and connection of the hose; the two brakemen act as nozzlemen and direct the stream. At a recent fire which occurred about the gas tank under a passenger car, the first engine was coupled up ready to act within two minutes after the alarm was sounded, while within seven minutes nine engines were on the scene.—Railway and Engineering Review.

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